TRANSACTIONS AND PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH.

VOLUME XIX.

INCLUDING SESSIONS LV. TO LVII.
(1890-91 TO 1892-93).

WITH FIVE PLATES, SIX WOODCUTS, AND ONE ZINCOGRAPH.

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CONTENTS OF VOL. XIX.

TRANSACTIONS AND PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH.

SESSION LVI.

MEETING OF THE SOCIETY,

Thursday, November 12, 1891.

Robert Lindsay, Esq., President, in the Chair.

The following Officers of the Society were elected for the Session 1891–92:—

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David Christison, M.D., F.S.A. Scot.

VICE-PRESIDENTS.

Professor F. O. Bower, D.Sc., F.R.SS. L. & E., F.L.S.
Robert Lindsay, Royal Botanic Garden.
Hugh F. C. Cleghorn, M.D., LL.D., F.R.S.E., F.L.S.
George Bird.

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William Somerville, Dr Œc., B.Sc., F.R.S.E.
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Malcolm Dunn.
William Sanderson.

Issued December 1891.

Honorary Secretary—Professor Sir DOUGLAS MACLAGAN, M.D., LL.D., P.R.S.E.

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Foreign Secretary—ANDREW P. AITKEN, M.A., D.Sc., F.R.S.E.

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Berwick—PHILIP W. MACLAGAN, M.D.
,, FRANCIS M. NORMAN, R.N.

Birmingham—GEORGE A. PANTON, F.R.S.E., 73 Westfield Road.

Bridge of Allan—ALEXANDER PATERSON, M.D.

Calcutta—GEORGE KING, M.D., F.R.S., Botanic Garden.
,, DAVID PRAIN, M.D., F.R.S.E., F.L.S., Botanic Garden.

Cambridge—CHARLES C. BABINGTON, M.A., F.R.S., Professor of Botany.
,, ARTHUR EVANS, M.A.

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Kilbarchan—Rev. G. ALISON.

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Lincoln—GEORGE MAY LOWE, M.D.

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Manchester—BENJAMIN CARRINGTON, M.D., Eccles.

Melbourne, Australia—Baron FERDINAND VON MUELLER, M.D., K.C.M.G., F.R.S.

Nova Scotia—Professor GEORGE LAWSON, LL.D., Dalhousie.

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Perth—F. BUCHANAN WHITE, M.D., F.L.S.

Saharunpore, India—J. F. DUTHIE, B.A., F.L.S.

Silloth—JOHN LEITCH, M.B., C.M.

St Andrews—Professor M'INTOSH, M.D., LL.D., F.R.SS. Lond. and Edin.

Wellington, New Zealand—Sir JAMES HECTOR, M.D., K.C.M.G., F.R.SS. Lond. and Edin.

Wolverhampton—JOHN FRASER, M.A., M.D.

Mr Thomas Jamieson was admitted a non-Resident Fellow of the Society.

The Transactions and Proceedings of the Society during the Session 1890–91, which had been issued to Members in parts in course of the Session, were laid on the table.

Presents to the Library, Museum, and Herbarium at the Royal Botanic Garden were announced.

The Curator exhibited from the Royal Botanic Garden a spadix of *Ptychosperma elegans*, with ripe fruit, from a tree over 50 feet high in the Palm House; a large plant of *Saxifraga longifolia vera*, and a collection of New Zealand species of *Veronica*.

Mr John Campbell exhibited blooms of *Escallonia macrantha*, *Veronica speciosa* var., and *Passiflora* "Constance Elliot," from plants growing in the open air in his garden at Ledaig, Argyleshire.

The retiring President, Mr Robert Lindsay, delivered the following Address:—

Gentlemen,—It is now my duty to demit the high office to which you did me the honour of electing me, and I have to acknowledge the uniform kindness and sympathy which I have received at your hands, and to return you my most cordial thanks for the support thus accorded me.

We are now entering on the fifty-sixth session of the Botanical Society, and I venture to affirm that, from the success which has uniformly attended it during that long period, we may confidently anticipate greater results in the future. Last Session has been a prosperous one, and many valuable and interesting communications have been made. The success which has attended the printing and issuing of the Transactions, at short intervals, is so decided as to render a return to the old method well-nigh impossible. Authors have now the satisfaction of knowing that their papers will be printed and issued immediately after they have been read before the Society, instead of being held back until the close of a Session, and even until far into a new one, to be published

in one volume or part. The rapid interchange of thought characteristic of the present time, and the importance of priority of publication, have rendered the new departure absolutely necessary. That it will have a good effect on the future prosperity of our Society is certain. I need not refer to the papers themselves, as they are, or at least may be, now well known to you all. There is one original feature, however, to which I ought to allude, viz., the series of Commentaries on British Plants, by Professor Bayley Balfour and Dr Muirhead Macfarlane, in which were described the structure of the wood of indigenous trees and shrubs, illustrated by means of the micro-lantern. I am sure that every one who had the privilege of seeing those lantern-projections will join with me in expressing a hope that exhibitions of a similar character may form a prominent part of our proceedings in future. Nothing can possibly be better adapted for teaching purposes.

I am glad to be able to congratulate the Society upon the fact that its membership has been fully maintained during the past session. While, on the one hand, I have to record the following losses by death:—

Foreign Honorary Fellow—1.
- Dr Carl von Nägeli, Professor of Botany and Director of the Botanic Garden, Munich.

Corresponding Fellow—1.
- Dr R. Schomburgk, Director of the Government Botanic Garden, Adelaide.

Ordinary Fellows—4.
- Thomas J. Call, M.D., Ilkley.
- John Gair, Falkirk.
- Henry Cadogan Rothery, M.A., F.L.S. London.
- William Thomson, F.R.C.S.E.

Associate—1.
- Andrew Brotherston, Kelso.

I have, on the other hand, to note the following additions to the list of members:—

British Honorary Fellow—1.
- Hugh Francis C. Cleghorn, M.D.

Foreign Honorary Fellows—4.
- Dr Max Cornu, Director of the Jardin des Plantes, Paris.
- Dr Adolph Engler, Professor of Botany and Director of the Imperial Botanic Garden, Berlin.

Dr Robert Hartig, Professor of Forestry, Munich.
Dr Edouard de Regel, Director of the Imperial Botanic Garden, St Petersburg.

Ordinary Fellows—14.

Thomas Berwick.
Richard Brown, C.A.
Alexander Edington, M.B.
George Hunter, M.D., F.R.C.S.E.
Thomas Jamieson, F.I.C.
J. Melvin Lowson, B.Sc.
David Prain, M.D.
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J. Pentland Smith, B.Sc.
W. Maxwell Tress.
R. B. White of Ardarroch.
John Wilson, D.Sc.
J. C. Wright, F.R.S.E.

Corresponding Fellow—1.

Augustine Henry, M.D.

Associates—3.

James Macandrew. James Shaw. Charles Taylor.

And the numerical strength of the Society is now the following:—

Honorary Fellows, 31.
Ordinary Fellows, 313.
Corresponding Members, 63.
Lady Associates, 9.
Associates, 31.

Giving a total Membership of 447.

I have had some difficulty in selecting a topic on which to make a few remarks before demitting the office to which you called me; but I have chosen a subject to which I have given some attention for a few years past, viz., New Zealand Veronicas, and which I now beg to submit to your notice.

The genus *Veronica* is by far the largest of flowering plants in New Zealand: nowhere else is the genus so abundantly represented, and in no other country do so many large shrubby forms exist.

A great number of these have now been introduced into this country, and have been found to be admirably adapted for many garden purposes. Perhaps nowhere in this country are to be found so many different species of these New Zealand Veronicas, thriving so well, as in the Edinburgh Botanic Garden; and a few remarks regarding their value, chiefly from a horticultural point of view, may not be altogether out of place here.

There are about sixty species indigenous to New Zealand; and, with one exception, they are not found in any other country. The solitary exception is *Veronica elliptica*, which

occurs also at Cape Horn and on the Falkland Islands. They form a most conspicuous feature of the vegetation of New Zealand by the beauty and ubiquity of the various species of large bushes so many of them form, and also by the remarkable forms many of them present. The species are difficult of discrimination. Numerous intermediate forms exist between many apparently distinct ones. They vary extremely in all their organs, and appear to hybridise freely in a natural state; consequently very great confusion exists as to their correct nomenclature. Nearly every genus of any magnitude in the colony shows variability to a remarkable degree, but in none is there so extreme variability to be found as in these Veronicas. Although many handsome shrubs have been introduced from New Zealand into our gardens of recent years which are decided acquisitions, such as the various species of *Olearia*, *Senecio*, &c., and there are many other species and genera yet to be introduced, of great beauty and hardiness, from high elevations on the New Zealand mountains, yet none will be found more valuable for garden purposes generally than the various species of *Veronica*. Many of them are indeed most beautiful plants: from the tiny *V. Bidwilli*, a little trailing species, to the dense and compact *V. Traversii*, 6 feet in height, there is not one but is worthy of the most careful cultivation and attention.

One of the earliest to be introduced was the very handsome but tender *V. speciosa*, R. Cunn. This has large, leathery, entire, and shining leaves, with dense racemes of dark purple flowers. It is a native of the northern island, and is found near the sea-coast. All the species that inhabit these districts in New Zealand are too tender for out-door culture in this country during winter, except in a few mild districts near the sea, where they flourish in great luxuriance for long periods without being injured by frost. *V. salicifolia*, Forst., *V. elliptica*, Forst., *V. Lavaudiana*, Raoul, *V. parviflora*, Vahl, *V. diosmæfolia*, R. Cunn., all found near the sea-coast, are among the tenderest kinds we have in cultivation, and were very early introduced into this country. Some beautiful hybrids of *V. salicifolia* crossed with *V. speciosa*, also hybrids between *V. elliptica* and *V. speciosa*, have been raised in this country, but chiefly in France. One of the first hybrids obtained was *V. Andersoni.*

This, the result of a cross between *V. salicifolia* and *V. speciosa*, was raised by the late Isaac Anderson Henry over forty years ago. It is still one of the best. All the above require protection during winter. As greenhouse plants, either planted out or grown in pots, they are most effective, and lend a pleasant variety at all times with their bright-shining foliage, and compact bush-like habit. They are free-flowering plants, particularly the hybrid varieties, which produce handsome racemes of flowers of various shades of blue, red, or white. A very handsome variegated-leaved form of *V. Andersoni*, which originated as a sport from it, was at one time in general use as a summer bedding plant, and is still one of the finest variegated plants in existence.

It is in the out-door garden, however, that the value of New Zealand veronicas will be most appreciated, and there are fortunately a large number of species well fitted to bear all the vicissitudes of our fickle climate; and it is those species that I wish particularly to bring under your notice to-night. The hardiest of all the species are those described by Sir Joseph D. Hooker in the Handbook of the New Zealand Flora, and which form section 4 of his arrangement of the genus. These consist of some six species found at altitudes of from 3000 to 8000 feet on the ice-clad slopes of the New Zealand mountains. Thoroughly alpine in character, they have a very curious appearance, closely resembling some conifers, and, except when in flower, might readily be mistaken for such, rather than for veronicas of the ordinary type. *V. cupressoides*, Hook. f., forms a dense, erect-growing bush, reaching a height of about 4 feet. In cultivation, it flowers very sparingly at the tips of the branches. The flowers are white, tinged with violet. It is, however, for the fine upright habit and evergreen branches and foliage that the plant is valued. It is of easy growth in ordinary soil, is very suitable for planting in beds alone or along with other plants in borders, and is a choice plant for the alpine garden.

A beautiful golden variegated sport has been observed on this species; and no doubt, when this plant is more widely distributed throughout the country, these sports will become more numerous, and we shall probably have variegations similar to those that obtain at present among conifers, to which they bear so striking a likeness.

V. cupressoides, var. *variabilis*, N.E.Br., is one of the most useful and ornamental of this group. It differs from the type very much in being dwarfer, more spreading in habit, and in having light green foliage, almost golden-coloured at times. It grows from 8 to 10 inches only in height, but spreads from 3 to 4 feet wide when old. It is unsurpassed among dwarf shrubs for the rockery, where it forms dense cushions of shapely growth, having all the appearance of a dwarf *Retinospora*. It is of the easiest culture, and will thrive in any soil or position except in very dry places; drought is the only thing that seems to affect it. The flowers, which are sparingly produced, are white with pink anthers. This fine plant was introduced into this country in 1876 by the late Mr Anderson Henry, under the name of *V. salicornioides*, under which name it is known in gardens both in this country and in New Zealand.

V. Hectori, Hook. f., is one of the most remarkable plants of the genus. It is an upright-growing species, 1 to 2 feet high, with rounded branches; the leaves are closely imbricated and reduced to mere scales; the whole plant is greyish-green in colour. An exceedingly hardy species, coming as it does from an altitude of from 7000 to 7500 feet on the Southern Alps, no frost we ever have in this country can at all affect it. The first living plant of *V. Hectori* was introduced into this country in 1888 by Mr Dunn of Dalkeith Gardens, and it now forms one of the chief attractions in the rock garden at the Royal Botanic Garden. It has not yet flowered in cultivation, but grows freely; unlike most of the species, it does not root readily from cuttings.

V. lycopodioides, Hook. f., resembles the latter, but differs chiefly in having square stems, which are not so thick; the leaves are sharp-pointed, and the colour of the plant is dark green; the habit is not so erect, but more spreading than in *V. Hectori*. In appearance it resembles *Andromeda tetragona* very closely.

V. Armstrongi, Kirk, is a compact, graceful shrub, about a foot high; the leaves and branches are light green in colour, and the stems have a miniature tree-like appearance, somewhat resembling a dwarf juniper. Belonging to this section of *Veronica* are *V. tetragona*, Hook., *V. tetrasticha*, Hook. f., and the true *V. salicornioides*, Hook. f., which have

not yet been introduced. The manner in which these veronicas shed their leaves is remarkable. The smaller branches are articulated with the stem and fall off bodily, leaving a well-defined scar, similar to what is found in some conifers. They also exhibit a peculiar heterophyllous condition, which in a former communication to the Society * I pointed out, stating that this was probably due to a reversion to the juvenile condition of the plants. Since then seedlings have been raised of *V. cupressoides*, var. *variabilis*, which entirely bears out the conjecture then indicated.

There is a large number of species of a totally different character from the preceding, in having larger foliage and handsomer flowers. These come from altitudes of 2500 to 5000 feet, and are also quite hardy in this country. They number about twenty species, all differing from each other in some respects, and yet linked so closely together that one is forced to the conclusion that many of them are but varieties of each other. They may be roughly divided into those having the leaves more or less glaucous, and those with more or less glabrous leaves.

V. pinguifolia, Hook. f., represents the former. In cultivation it forms a compact shrub, about 18 inches in height, having thick, very glaucous foliage, and stout erect branches, which spread when old about a yard across. Throughout the summer it becomes covered with small spikes of white flowers, giving the plant the appearance at a distance of being sprinkled with snow. *V. carnosula*, Hook. f., *V. Godefroyana*, Decne, and *V. amplexicaulis*, Arm., are of the same type, differing chiefly in size of foliage and flower. *V. pimelioides*, Hook. f., and *V. glauco-cærulea*, Arm., have also glaucous foliage; but the leaves are much smaller and narrower, and the habit more spreading. Of a quite different type is *V. Colensoi*, Hook. f., *glauca*, which is a larger and much more erect shrub than any of the preceding. All those kinds having glaucous foliage are among the hardiest, besides being among the most ornamental of the genus.

The well-known *V. Traversii*, Hook. f., may be taken as representing those having glabrous foliage. It is an erect-growing shrub, attaining a height of from 6 to 7 feet, and naturally forms beautiful shapely bushes, and, when covered

* Trans. Bot. Soc., vol. xvii.

with its longish racemes of lilac-white flowers, is an exceedingly handsome object. Others of this type, though differing in size and other respects, are *V. rakaiensis*, *V. monticola*, Arm., *V. lævis*, Benth., *V. buxifolia*, Benth., and *V. anomala*. Of a different type is *V. linifolia*, Hook. f., a small alpine herb about 6 inches high, a very distinct hardy species, having entire glabrous leaves about an inch long and very narrow. The flowers are axillary, large, white streaked with rosy purple; a most useful rockwork plant, quite distinct from any other.

A number of very beautiful species, which are found at altitudes below 2500 feet, are too tender to withstand our severe winters, but pass through our ordinary winters in safety; they can only be termed half-hardy, and include the handsome *V. Hulkeana*, F. Muell., which forms a lax-growing bush 2 to 3 feet high; the leaves are about an inch long, serrate, and leathery in texture. The flowers appear in May and June; they are arranged on a spike about 1 foot long, and are of a delicate mauve colour. *V. Fairfieldi* resembles the latter somewhat, but is not so high, scarcely 1 foot in height; the leaves are serrate, having a brownish tinge at the edges. The flowers are larger, not so lilac as in *V. Hulkeana*, and the spikes are shorter and more racemose. It is of recent introduction, having been raised from seed by Mr Martin of the Fairfield Nurseries, Dunedin, and is probably a hybrid of *V. Hulkeana*. *V. Lyallii*, Hook. f., a neat dwarf shrub, with deeply-toothed leaves and racemes of violet-coloured flowers, is one of the hardiest of this set. *V. cataractæ*, Forst., seems to be a large-leaved form of *V. Lyallii*, while the beautiful trailing *V. Bidwillii*, Hook., seems to be a small-leaved form.

Other half-hardy species which we have in cultivation are *V. ligustrifolia*, A. Cunn., *V. Lewisii*, Arm., *V. chathamica*, Buch., *V. Kirkii*, Arm., *V. epacridea* (?), and *V. vernicosa* (?).

Although the above species cannot be depended upon in all seasons, yet they are sufficiently hardy to withstand our ordinary winters; not one of those mentioned was injured during last winter at Edinburgh; and as they include some of the finest flowering species, they are worthy of being extensively planted, particularly near the sea-coast, where all the New Zealand veronicas flourish most freely. In very

cold districts a few cuttings may be put in during August, and placed in a cold frame they will root readily, and be well fitted in spring to be planted out in room of any that may have been too much injured. Several fine species have still to be introduced from New Zealand, particularly *V. macrantha*, Hook. f., and *V. Benthami*, Hook. f.; the former, at least, should be quite hardy in this country, as it is found at from 3000 to 6000 feet altitude. It has the largest flowers of any of the species; they are pure white, and about 1 inch across. *V. Benthami* is also a most desirable species, and has bright blue flowers. All attempts to introduce these fine species alive into this country have hitherto failed, the long journey having proved fatal to them. The difficulty will be overcome by sending seeds home, when they are procurable.

New Zealand veronicas are easily raised from seed, and self-sown seedlings of many of the species spring up spontaneously near where old plants are growing; and while much may be done by selecting varieties better suited in one respect or another for garden purposes, it is to the hybridist that we shall have mainly to look for improved varieties. Some good results have already been obtained by crossing the tender kinds only. Nothing has as yet been done in the way of hybridising the hardy species; but there is little reason to doubt that, by crossing these with the tender and more showy kinds, we might succeed in raising an improved race of veronicas, perfectly capable of standing through our worst winters. The numerous species, as they now exist, are very suggestive of their having originated at some distant date, from one or two types, as natural hybrids; and this is probably the cause of the great variation now found in the genus. Be that as it may, the artificial crossing of several of the species offers a tempting means of throwing additional light upon, if not of solving, the problem of their origin.

Nearly all the species naturally form compact shapely bushes, and do not require much in the way of pruning or trimming into shape. Their varied evergreen foliage and different-coloured flowers render them very attractive at all seasons. They are not particular as to soil, and they may be increased rapidly and without much trouble from cuttings. Few plants are so useful for various purposes as those New Zealand speedwells. They are very effective

when planted in groups on lawns, or singly in borders along with other shrubs. Many of them are peculiarly well adapted for the rock-garden, their unique appearance, compact habit of growth, combined with their extreme hardiness, all tending to make them invaluable for that style of gardening. They may also be used advantageously for winter bedding plants, or for edgings to beds in summer. For window-boxes in towns the dwarf kinds are extremely useful, as they resist the injurious effects of smoke better than most plants; and, possessing as they do so many advantages for decorative purposes, they ought to become more widely known than they are at the present time.

Species of Veronica from New Zealand, cultivated in the Royal Botanic Garden, Edinburgh, in 1891.

Hardy Species.

Veronica Hectori, Hook. f., 7–7500 ft. altitude.
,, lycopodioides, Hook. f., 4–5000 ft. altitude.
,, cupressoides, Hook. f., 4000 ft. altitude.
,, ,, var. variabilis, N.E.Br.
,, Armstrongi, Kirk.
,, carnosula, Hook. f., 5000 ft. altitude.
,, pinguifolia, Hook. f., 5000 ft. altitude.
,, amplexicaulis, Arm., 5000 ft. altitude.
,, buxifolia, Benth., 5000 ft. altitude.
,, lævis, Benth., 2–6000 ft. altitude.
,, Godefroyana, Decne.
,, monticola, Arm., 3–4500 ft. altitude.
,, Colensoi, Hook. f., 3–5000 ft. altitude.
,, ,, var. glauca.
,, Traversii, Hook. f., 4000 ft. altitude.
,, rakaiensis, Arm., 2–4000 ft. altitude.
,, glauco-cœrulea, Arm., 2–5000 ft. altitude.
,, pimelioides, Hook. f., 2–4000 ft. altitude.
Veronica linifolia, Hook. f., 2500–4000 ft. altitude.
,, anomala, Arm.

Half-hardy Species.

,, Lyallii, Hook. f., 2–4000 ft. altitude.
,, Bidwillii, Hook., 2-3000 ft. altitude.
,, cataractæ, Forst.
,, Kirkii, Arm.
,, epacridea ? 5–6000 ft. altitude.
,, vernicosa, Hook. f., 1500–3000 ft. altitude.
,, Lewisii, Arm.
,, ligustrifolia, A. Cunn.
,, chathamica, Buch.
,, Hulkeana, F. Muell., 1500–2000 ft. altitude.
,, Fairfieldi, Hort.

Tender Species.

,, diosmæfolia, R. Cunn., sea-coast.
,, elliptica, Forst., sea-coast.
,, parviflora, Vahl, sea-coast.
,, salicifolia, Forst.
,, Lavaudiana, Raoul.
,, Andersoni, hybrid.
,, speciosa, R. Cunn., sea-coast.
,, elegans.

On the motion of Dr CLEGHORN, the thanks of the Society were given to Mr Lindsay for his address.

The following Papers were read :—

ON ROOT-HAIRS. By THOMAS JAMIESON, F.I.C., Fordyce Lecturer on Agriculture, University of Aberdeen.

On Temperature and Vegetation in the Royal Botanic Garden, during July, August, September, and October 1891. By Robert Lindsay, Curator of the Garden.

JULY.

The month of July was for the greater part changeable and inclement; there was a marked absence of real summer warmth. The lowest night temperature was 42°, which occurred on the 10th of the month, and the highest 54°, on the 17th. The lowest day temperature was 63°, on the 16th, and the highest 79°, on the 17th. Roses were unusually fine, although late in commencing to flower. Herbaceous plants generally were also good. On the rock-garden 252 species and well-marked varieties came into flower as against 204 for the corresponding month last year. A few of the more interesting were:—*Aquilegia pyrenaica, Anomatheca cruenta, Astragalus alopecuroides, Calamintha patavina, Campanula Waldsteiniana, Dianthus neglectus, D. cinnabarinus, Cyananthus lobatus, Epilobium obcordatum, Eriogonum aureum, Gentiana septemfida, G. tibetica, Hypericum reptans, Galium rubrum, Linaria origanifolia, Mimulus roseus, Palava flexuosa, Pentstemon speciosum, Potentilla lanuginosa, Saxifraga diversifolia, Senecio laxiflora, Swertia multicaulis, Veronica elliptica,* and *V. rakaiensis,* &c.

Readings of exposed Thermometer at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during July 1891.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	53°	70°	75°	17th	54°	59°	79°
2nd	49	61	75	18th	50	70	76
3rd	47	56	68	19th	48	64	72
4th	46	58	72	20th	52	56	74
5th	44	55	71	21st	53	59	69
6th	53	66	70	22nd	47	59	69
7th	44	62	68	23rd	53	60	75
8th	45	61	68	24th	49	64	69
9th	49	54	69	25th	48	57	72
10th	42	64	76	26th	49	50	71
11th	48	57	67	27th	52	59	67
12th	52	58	72	28th	43	56	64
13th	50	65	74	29th	42	60	68
14th	51	64	70	30th	50	58	71
15th	50	64	73	31st	51	53	64
16th	49	54	63				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of July 1891.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·587	67·1	55·6	63·9	52·5	S.W.	Cir. St. Cum.	1 5	S.W.	0·125
2	29·609	70·4	52·9	61·7	57·0	S.	Cum.	5	S.	0·033
3	29·571	68·5	51·0	57·1	54·8	W.	Cum.	9	W.	0·210
4	29·812	63·9	48·9	59·9	55·1	W.	Cum.	5	W.	0·002
5	29·803	66·8	47·7	58·1	53·2	E.	Cum.	10	S.	0·365
6	29·483	64·2	55·2	61·9	57·3	S.W.	Cum.	1	S.W.	0·157
7	29·342	67·0	48·0	59·9	55·2	W.	...	0	...	0·002
8	29·649	66·8	50·1	60·2	56·1	N.	Cum.	8	N.	0·162
9	30·020	66·4	51·9	55·1	51·3	N.	Cum.	10	N.	0·005
10	29·979	62·6	46·1	62·0	56·8	S.W.	...	0	...	0·000
11	29·902	71·6	51·1	57·4	53·6	S.W.	Cum.	10	S.W.	0·000
12	29·900	62·9	53·9	59·7	55·9	S.W.	Cum.	10	S.W.	0·012
13	30·101	65·6	53·2	64·7	59·9	S.W.	Cum.	4	S.W.	0·025
14	30·324	69·6	55·1	62·3	58·8	N.E.	Cum.	2	N.E.	0·000
15	30·167	66·1	52·7	59·9	54·8	E.	Cir. St. Cum.	5 1	S. E.	0·343
16	29·768	66·0	52·9	56·3	56·1	S.W.	Nim.	10	S.W.	0·035
17	29·660	60·7	56·1	60·7	60·0	S.W.	Cum.	10	S.W.	0·004
18	29·753	74·1	53·9	68·8	62·1	S .E.	Cum.	2	S.E.	0·000
19	29·775	70·8	51·5	60·9	56·3	N.E.	Cum.	10	S.	0·002
20	29·780	66·6	55·1	59·4	57·2	S.W.	Cum.	10	S.W.	0·040
21	29·774	63·0	56·9	61·1	58·8	S.W.	Cum.	9	S.W.	0·335
22	29·676	64·0	50·5	60·2	57·1	W.	Cum.	9	W.	0·540
23	29·854	65·0	55·1	60·8	57·2	N.	Cum.	10	N.	0·005
24	29·823	67·6	51·8	62·0	55·8	W.	Cum.	2	W.	0·000
25	29·942	65·9	50·9	59·1	53·8	W.	Cum.	6	W.	0·000
26	29·920	69·8	51·9	65·3	59·9	W.	Cir. Cum. Cum.	3 2	W.	0·000
27	29·592	67·7	54·7	57·2	52·2	N.W.	Cum.	2	N.W.	0·005
28	29·604	64·9	46·5	57·7	51·0	N.W.	Cir. St. Cum.	5 2	N.W.	0·065
29	29·442	63·8	46·0	58·3	53·2	W.	Cum.	4	N.	0·070
30	29·694	64·5	53·0	57·2	53·0	N.E.	Cum.	10	N.E.	0·000
31	29·897	65·2	51·3	58·1	55·6	E.	Cum.	10	E.	0·000

Barometer.—Highest Reading, on the 14th, =30·324. Lowest Reading, on the 7th, =29·342. Difference, or Monthly Range, =0·982. Mean=29·781.

S. R. Thermometers.—Highest Reading, on the 18th, =74°·1. Lowest Reading, on the 29th, =46°·0. Difference, or Monthly Range, =28°·1. Mean of all the Highest =66°·6. Mean of all the Lowest=52°·0. Difference, or Mean Daily Range, =14°·6. Mean Temperature of Month=59°·3.

Hygrometer.—Mean of Dry Bulb=60°·2. Mean of Wet Bulb=55°·8.

Rainfall.—Number of Days on which Rain fell=22. Amount of Fall, in inches, =2·542.

A. D. RICHARDSON,
Observer.

AUGUST.

August was an exceedingly cold and wet month. No really warm days occurred, and altogether the month was a most unfavourable one. The lowest night temperature was 34°, which occurred on the 30th, and the highest 55°, on the 18th. The lowest day temperature was 59°, on the 23rd, and the highest 77°, on the 19th. On the rock-garden 84 species came into flower as against 81 during last August. Amongst the most conspicuous were:—*Cheiranthus Allionii*, *Carlina subcaulescens*, *Cyclamen hederæfolium*, *Dalibarda repens*, *Dianthus Atkinsoni*, *D. monspessulanus*, *Delphinium velutinum*, *Epilobium Fleisherii*, *Gentiana arvernensis*, *Helleborus niger angustifolius*, *Lilium dalmaticum*, *L. auratum*, *Lobelia cardinalis*, *Mimulus cardinalis*, *Spiræa gigantea*, *Stobæa purpurea*, *Tricyrtis australis*.

Readings of exposed Thermometer at the Rock Garden of the Royal Botanic Garden, Edinburgh, during August 1891.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	43°	64°	72°	17th	44°	52°	66°
2nd	42	65	69	18th	55	62	76
3rd	45	55	66	19th	47	68	77
4th	46	54	62	20th	47	56	67
5th	50	62	66	21st	49	54	67
6th	45	58	72	22nd	48	55	66
7th	49	54	69	23rd	52	55	59
8th	54	57	67	24th	47	56	66
9th	53	60	66	25th	52	60	67
10th	45	57	70	26th	48	53	66
11th	45	50	68	27th	47	57	68
12th	51	56	65	28th	44	58	64
13th	48	54	69	29th	36	54	66
14th	48	52	68	30th	34	56	76
15th	49	62	69	31st	43	57	63
16th	50	60	68				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of August 1891.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·799	65·8	45·8	63·1	56·2	W.	Cir. / Cum.	3 / 6	W.	0·000
2	29·604	67·1	48·9	60·0	55·2	S.W.	Cum.	9	S.W.	0·155
3	29·440	66·8	47·9	57·1	54·3	N.N.E.	Cum.	10	N.N.E.	0·545
4	29·528	62·3	51·9	54·8	53·9	E.N.E.	Cum.	10	E.N.E.	0·220
5	29·783	60·7	52·9	60·1	55·8	N.N.E.	Cum.	9	N.N.E.	0·015
6	29·902	61·7	49·4	57·6	54·3	W.N.W.	Cum.	7	N.W.	0·045
7	29·845	68·3	51·2	56·1	54·2	W.S.W.	Cum.	10	W.S.W.	0·075
8	29·818	65·8	55·8	59·9	58·2	W.S.W.	Nim.	10	W.S.W.	0·085
9	29·498	64·7	55·2	60·8	60·1	W.S.W.	Cum.	10	W.S.W.	0·660
10	29·714	63·7	50·5	59·0	57·6	N.	Cir. Cum.	6	N.	0·028
11	29·736	64·8	48·6	53·9	52·9	S.W.	Nim.	10	S.W.	0·002
12	29·430	62·7	50·9	56·8	53·8	S.W.	Nim.	10	S.W.	0·095
13	29·723	61·9	50·9	60·7	55·8	W.	Cir.	1	N.W.	0·095
14	29·738	66·8	52·9	55·3	55·1	E.N.E.	Nim.	10	E.N.E.	0·032
15	29·642	65·8	52·2	60·1	55·6	W.	Cir. / Cum.	4 / 1	S.W. / W.	0·000
16	29·849	65·1	52·9	58·5	53·3	S.E.	Cum.	8	N.W.	0·000
17	29·768	63·5	47·7	55·6	52·5	S.E.	Cum.	10	S.E.	0·162
18	29·496	63·2	55·0	62·7	58·9	S.E.	Cir.Cum. / Cum.	3 / 5	S.E.	0·010
19	29·423	69·9	51·8	64·0	57·2	S.E.	...	0	...	0·000
20	29·520	69·9	52·1	56·2	54·8	E.	Cum.	10	N.E.	0·025
21	29·432	60·8	53·7	55·1	54·2	N.N.E.	Cum.	10	N.E.	0·850
22	29·602	60·8	52·2	56·8	54·2	N.N.E.	Cum.	10	N.E.	0·002
23	29·712	63·7	52·3	55·8	51·3	N.	Cum.	5	N.	0·000
24	29·625	61·8	46·3	57·0	53·5	W.	Cum.	8	W.	0·140
25	29·215	61·8	55·7	60·5	55·9	W.S.W.	Cum.	10	W.S.W.	0·270
26	28·898	64·6	52·9	55·1	52·3	W.S.W.	Cir.Cum. / Cum.	4 / 2	W.	0·005
27	29·267	63·0	55·9	58·0	54·7	S.S.W.	Cum.	9	S.S.W.	0·150
28	29·312	62·3	46·7	54·6	51·8	W.S.W.	Nim.	10	W.S.W.	0·002
29	29·721	62·3	40·1	56·8	52·1	W.N.W.	...	0	...	0·030
30	29·911	63·6	40·7	55·6	51·3	Calm.	Cum.	2	S.W.	0·020
31	29·354	62·9	49·2	55·8	53·1	S.	Cum.	9	S.W.	0·150

Barometer.—Highest Reading, on the 30th, =29·911. Lowest Reading, on the 26th, =28·898. Difference, or Monthly Range, =1·013. Mean=29·590.

S. R. Thermometers.—Highest Readings, on the 19th and 20th, =69°·9. Lowest Reading, on the 29th, =40°·1. Difference, or Monthly Range, =29°·8. Mean of all the Highest=64°·1. Mean of all the Lowest=50°·6. Difference, or Mean Daily Range, =13°·5. Mean Temperature of Month=57°·3.

Hygrometer.—Mean of Dry Bulb=57°·8. Mean of Wet Bulb=54°·6.

Rainfall.—Number of Days on which Rain fell=26. Amount of Fall, in inches, =3·873.

A. D. RICHARDSON,
Observer.

SEPTEMBER.

The month of September was very changeable and unsettled, with frequent storms of wind and rain, yet in some respects it was the best month of the season. More really fine and warm days occurred than in any of the three months previous. The severe storm of wind and rain which took place on the 21st, and which caused so much destruction throughout the country, passed over without doing any serious damage in the garden. No frost occurred, and there was a fair amount of bright sunshine. Late-flowering herbaceous plants and annuals now reached their best. Those which flowered earlier mostly produced good seed, a large supply of which has been obtained for distribution. The lowest night temperature was 38°, which occurred on the 21st of the month, and the highest 54°, on the 14th. The lowest day temperature was 49°, on the 21st, and the highest 85°, on the 12th. On the rock-garden 41 species and varieties came into flower as against 47 for the corresponding month last year, amongst which were the following:—*Coreopsis verticillata, Gentiana alba, G. ornata, Gladiolus Saundersii, Crocus annulatus, C. imperati, C. pulchellus, C. speciosus, Colchicum maximum, Kniphofia Uvaria, K. nobilis, Potentilla formosa, Senecio pulcher, Veronica Lindleyana, V. longifolia subsessilis, Lilium auratum macranthum*, &c.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during September 1891.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	51°	61°	64°	16th	50°	55°	60°
2nd	42	60	66	17th	54	59	64
3rd	44	65	71	18th	54	57	63
4th	42	55	69	19th	49	60	64
5th	42	54	65	20th	45	50	54
6th	41	46	64	21st	38	44	49
7th	45	59	67	22nd	44	49	54
8th	37	47	60	23rd	40	50	62
9th	50	60	72	24th	42	50	68
10th	43	63	81	25th	43	52	68
11th	47	68	76	26th	45	58	61
12th	47	70	85	27th	43	51	57
13th	46	63	73	28th	41	53	64
14th	54	56	60	29th	49	54	66
15th	44	51	63	30th	43	55	65

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of September 1891.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours.		Hygrometer.		Direction of Wind.	Clouds.			Rainfall. (Inches.)
		Max.	Min.	Dry.	Wet.		Kind.	Amount.	Direction.	
		°	°	°	°					
1	28·800	64·4	53·9	61·0	56·0	S.W.	Cir.Cum. Cum.	2 4	S.W.	0·260
2	29·269	62·3	51·8	58·3	54·0	S.W.	Cum.	5	S.W.	0·002
3	29·815	62·8	45·1	58·3	52·3	W.S.W.	...	0	...	0·105
4	29·860	65·2	47·2	53·8	52·7	S.E.	Cum.	2	S.W.	0·015
5	29·856	61·8	46·2	55·0	51·9	S.W.	Cum.	10	S.W.	0·175
6	29·523	62·6	48·9	57·3	52·8	W.S.W.	Cum.	10	W.S.W.	0·032
7	29·783	62·3	47·0	56·7	51·9	W.	Cir. Cum.	1 1	N.W. W.	0·115
8	29·933	64·0	41·6	55·1	54·2	Calm	Nim.	10	Calm	0·192
9	29·869	63·7	49·8	63·0	60·9	S.W.	Cum.	6	S.W.	0·007
10	29·905	68·0	49·9	61·4	58·5	N.E.	...	0	...	0·000
11	29·922	74·1	52·2	65·7	62·6	W.N.W.	Cir. Cum.	2 2	N.W.	0·000
12	29·867	72·1	50·1	65·4	61·7	Calm	...	0	...	0·000
13	29·748	79·7	49·4	59·8	52·9	S.E.	Cir.	2	S.W.	0·023
14	29·599	69·4	57·0	59·4	59·2	W.S.W.	Nim.	10	W.S.W.	0·115
15	29·927	60·6	47·0	55·6	51·7	W.N.W.	Cum.	4	N.W.	0·011
16	29·881	61·1	52·8	56·4	54·2	W.	Nim.	10	W.	0·002
17	29·660	60·7	55·7	59·9	52·3	S.W.	Cum.	5	S.W.	0·017
18	29·492	61·9	55·3	58·0	55·6	W.	Cir. Cum.	3 2	W.	0·000
19	29·664	62·9	51·2	58·3	54·5	W.	Cir. Cum.	1 4	W.	0·048
20	29·618	60·9	48·0	52·0	52·0	N.N.E.	Nim.	10	N.N.E.	1·482
21	29·474	53·4	45·2	47·2	45·6	N.N.E.	Nim.	10	N.N.E.	0·376
22	29·837	50·1	46·2	49·2	45·9	N.N.E.	Cum. St.	10	N.N.E.	0·000
23	29·966	52·6	42·8	50·0	47·6	E.	Cum.	8	S.W.	0·075
24	29·809	57·7	45·4	52·6	51·4	E.	Nim.	10	S.W.	0·087
25	29·877	61·6	44·9	53·8	51·0	S.W.	Cum.	8	S.W.	0·265
26	29·231	62·9	48·4	57·0	52·6	S.W.	Cum.	4	S.W.	0·100
27	29·506	60·6	48·5	53·0	44·6	W.	Cum.	2	W.	0·045
28	29·667	57·0	50·7	55·4	53·9	W.S.W.	Cum.	10	W.S.W.	0·270
29	29·560	62·4	52·5	55·4	51·7	S.W.	Cum.	4	S.W.	0·045
30	29·461	61·7	46·1	55·4	51·1	S.	Cum.	5	S.W.	0·080

Barometer.—Highest Reading, on the 23rd, = 29·966. Lowest Reading, on the 1st, = 28·800. Difference, or Monthly Range, = 1·166. Mean = 29·679.

S. R. Thermometers.—Highest Reading, on the 13th, = 79°·7. Lowest Reading, on the 8th, = 41°·6. Difference, or Monthly Range, = 38°·1. Mean of all the Highest = 62°·7. Mean of all the Lowest = 49°·0. Difference, or Mean Daily Range, = 13°·7. Mean Temperature of Month = 55°·8.

Hygrometer.—Mean of Dry Bulb = 56°·6. Mean of Wet Bulb = 53°·2.

Rainfall.—Number of Days on which Rain fell = 25. Amount of Fall, in inches, = 3·944.

A. D. RICHARDSON, } *Observers.*
A. ANDERSON,

OCTOBER.

The month of October was on the whole favourable. The first frost this season took place on the 18th of the month, when the glass registered 32°. The thermometer was at or below the freezing point on eight occasions, indicating collectively 20° of frost for the month. The lowest readings were on the 18th, 32°; 23rd, 32°; 25th, 27°; 29th, 26°; 30th, 29°; and 31st, 26°.

The lowest day reading was 45°, on the 29th, and the highest 71°, on the 5th. Dahlias and other tender plants were destroyed by frost on the 23rd. Deciduous trees and shrubs were late in shedding their leaves. Autumn tints were most conspicuous on Scarlet and Hungarian Oaks, Tulip-tree, Beech; *Pavia flava*, *Amelanchier vulgaris*, *Azalea pontica*, and *Ampelopsis tricuspidata*. Amongst fruit-bearing trees or shrubs the best set are Hollies, Cotoneasters, and Gaultherias. Hardy Rhododendrons and Azaleas are fairly well set with flower-buds.

On the rock-garden 13 species came into flower during October, as against 23 from October 1890. Amongst those which flowered were:—*Crocus asturicus*, *C. Salzmannii*, *Erica ciliaris*, *Gentiana Kurroo*, *Gynerium argenteum*, *Helleborus altifolius*, *Kniphofia Saundersii*, *Oxalis lobata*, *Saxifraga Fortunei*. The total number which have flowered since January 1st is 1210; during the same period last year 1154 had flowered.

Register of exposed Thermometer at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during October 1891.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	44°	48°	65°	17th	39°	45°	57°
2nd	39	47	64	18th	32	35	67
3rd	40	52	64	19th	43	46	54
4th	50	58	65	20th	34	45	61
5th	46	50	71	21st	41	47	60
6th	43	52	61	22nd	38	44	54
7th	42	53	61	23rd	32	33	53
8th	41	50	64	24th	37	45	57
9th	45	61	61	25th	27	38	54
10th	39	42	65	26th	39	45	53
11th	40	46	60	27th	44	46	52
12th	40	50	62	28th	35	44	54
13th	38	47	53	29th	26	30	45
14th	40	42	56	30th	29	35	47
15th	37	42	52	31st	26	30	47
16th	36	47	53				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of October 1891.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·370	61·0	47·0	50·0	48·5	S.S.W.	Cum.	10	S.S.W.	0·044
2	29·584	55·8	41·7	49·0	47·3	N.	Cum.	10	N.	0·005
3	29·860	55·8	44·3	54·0	52·0	S.W.	Cum.	10	S.W.	0·002
4	29·934	61·6	52·4	58·2	53·6	S.W.	Cir.	6	S.W.	0·002
5	29·743	61·8	49·9	52·3	48·5	S.	Cum.	6	S.W.	0·020
6	28·953	57·6	51·9	55·3	52·9	S.E.	Cum.	10	S.E.	0·115
7	29·200	58·8	46·2	53·1	49·1	S.	Cir. Cum.	2 2	S.	0·020
8	29·533	57·8	43·5	51·6	48·2	S.	Cir.	3	W.	0·305
9	29·269	59·9	49·1	53·1	49·1	S.W.	Cum.	10	S.W.	0·022
10	29·626	59·8	43·0	49·9	46·6	S.S.W.	...	0	...	0·000
11	29·261	57·8	43·0	50·1	47·7	S.E.	Cum.	10	S.	0·017
12	29·125	56·8	42·0	49·2	46·0	S.W.	...	0	...	0·045
13	29·188	55·4	42·2	47·0	44·6	S.S.E.	Cum.	2	S.S.E.	0·348
14	28·753	52·8	43·7	49·1	44·1	S.S.W.	...	0	...	0·240
15	29·163	53·5	44·0	44·0	43·6	S.	Nim.	10	S.	0·224
16	29·089	50·2	38·0	49·3	47·9	S.E.	Cum.	10	S.	0·070
17	29·365	54·8	43·4	48·1	45·4	W.	Cum.	8	W.	0·000
18	29·770	54·8	35·0	44·0	43·1	W.	...	0	...	0·085
19	29·131	55·0	43·0	47·8	46·0	W.S.W.	Cum.	9	W.S.W.	0·000
20	29·237	51·7	35·4	44·2	42·7	S.	...	0	...	0·000
21	28·951	53·5	43·8	47·9	45·8	E.	Cum.	10	S.E.	0·000
22	28·971	53·5	42·4	46·6	44·8	S.	Cum.	10	S.	0·000
23	29·226	50·8	34·5	35·0	34·9	S.W.	Cir.	3	S.W.	0·000
24	29·601	49·3	34·1	42·8	42·7	W.	Cir.	1	W.	0·000
25	29·851	49·6	29·9	33·0	32·2	W.	...	0	...	0·010
26	30·088	47·8	32·0	47·0	46·0	N.E.	Cum.	10	N.E.	0·000
27	30·210	51·2	46·8	48·2	44·2	E.N.E.	Cum.	10	E.N.E.	0·000
28	30·272	49·8	38·0	45·6	43·1	S.E.	Cum.	10	S.E.	0·000
29	30·392	50·9	29·0	32·6	32·0	S.	...	0	...	0·000
30	30·563	43·9	31·5	37·2	37·1	S.	Cum. St.	10	S.	0·000
31	30·651	44·1	30·3	32·9	32·9	W.	...	0	...	0·020

Barometer.—Highest Reading, on the 31st, =30·651. Lowest Reading, on the 14th, =28·753. Difference, or Monthly Range, =1·898. Mean=29·546.

S. R. Thermometers.—Highest Reading, on the 5th, =61°·8. Lowest Reading, on the 29th, =29°·0. Difference, or Monthly Range, =32°·8. Mean of all the Highest =54°·1. Mean of all the Lowest=41°·0. Difference, or Mean Daily Range, =13°·1. Mean Temperature of Month=47°·5.

Hygrometer.—Mean of Dry Bulb=46°·4. Mean of Wet Bulb=44°·6.

Rainfall.—Number of Days on which Rain fell=18. Amount of Fall, in inches, =1·594.

A. D. RICHARDSON,
Observer.

On Temperature and Vegetation in the Royal Botanic Garden, Glasgow, during July, August, September, and October. By Robert Bullen, Curator of the Garden.

JULY.

This was the driest summer month experienced here since July 1885, but the temperature was much higher this month. The readings on the shaded thermometer varied during the month from 63° to 76°, and on that in the sun from 75° to 101°. The lowest night temperature was 44° and the highest 56°. Dull mornings were frequent, but generally followed by bright days; altogether, a bright sunny month. Trees, shrubs, and various crops suffered much by lack of moisture; numerous pansies, &c., died out in the open borders, but the various Californian annuals and the usual assortment of bedding-out plants were very effective, the bright weeks having brought out the natural brilliancy of their flowers. The leaves had a parched appearance.

AUGUST.

In striking contrast to last month, this was mostly cloudy and wet, the latter part unusually so, and the rains were often so heavy as to greatly discount the previous harvest prospects. At this time the prospect was further darkened by the rapid development of the potato-blight in many districts of the country, the meteorological conditions being highly favourable. Occasional bright days were recorded, and bright sunshine, but generally of short duration.

The highest reading of the sun thermometer was 90° on the 18th, but frequently the reading was below 80°. The temperature in the shade was also low for the month. Half-hardy plants made good growth and bloomed well until the stormy night of the 25th, which gave them a very tattered appearance.

SEPTEMBER.

This was a rainy, stormy month; probably one of the viest known in meteorological history. The storms and floods were most injurious to garden and farm crops of all

descriptions, and over a large part of the country. In a few districts the harvest was fairly well gathered, but mostly the reverse was the case, and the potato crop a comparative failure.

Owing to the continued wet weather and immunity from frost, many hardy shrubs, both deciduous and evergreen, were still growing at the end of the month.

Rhododendron ponticum and its progeny mostly made a second growth. All the tender and some of the so-called hardy annuals died an early death from cold and damp.

OCTOBER.

A chilly, wet, and comparatively sunless month. The fine days recorded as such from beginning to end only count one week, the remainder being very coarse. Floods and storms were frequent and severely felt; farm and garden land suffered much from the immense access of water, apart from the crops that were either in or on the ground; it will make winter tillage in heavy land difficult. The only vegetation which has derived benefit by the deluge are those trees whose roots run deep. Grass continued to grow at the end of the month, and the fall of the leaf is this season much later than is usual here. A storm of great severity was experienced on the night of the 13th, leaving behind it much disaster. The day temperature was nearly normal, but the night temperature fell rapidly after the 22nd; the lowest reading was 6°, on the night of the 24th. Total frost 17°, and thrice at freezing point.

MEETING OF THE SOCIETY,

Thursday, December 10, 1891.

Dr Cleghorn, Vice-President, in the Chair.

Andrew Semple, M.D., F.R.C.S.E., was elected and admitted Resident Fellow of the Society.

The death of Dom Pedro II., Ex-Emperor of Brazil, and Honorary Fellow of the Society, was announced.

The death of Dr Hermann Hoffman, Professor of Botany in the University and Director of the Botanic Garden, Giessen, a Corresponding Member of the Society, was announced.

The Treasurer submitted the following Statement of Accounts for Session 1890–91:—

Receipts.

Annual Subscriptions, 1890–91, 76 at 15s.,	£57 0 0
Do. do., 1889–90, 1 do.	0 15 0
Compositions for Life Membership,	39 18 0
Transactions sold,	14 4 9
Interest received,	0 14 10
Subscriptions to Illustration Fund,	2 0 0
Receipts,	£114 12 7

Payments.

Printing Transactions, Billets, &c.,	£68 13 6
Lithographing Plates, and Engraving Woodcuts,	4 1 3
Assistant Secretary's Salary,	15 0 0
Rooms for Meetings, and Tea,	6 2 0
Commission paid to Collector,	1 15 2
Postages, Carriages, &c.,	12 6 11
Sundries,	0 13 0
Payments,	£108 11 10
Balance of Receipts,	6 0 9
	£114 12 7

Issued December 1891.

STATE OF FUNDS.

Amount of Funds at close of Session 1889–90,	£63 13 5	
Increase during Session 1890–91, . . .	6 0 9	
		£69 14 2
Being :—Sum on Deposit Receipt with Union Bank of Scotland, ...	£60 0 0	
Sum on Current Account with do. .	9 14 2	
		69 14 2

I have compared the above with the Accounts and Vouchers, and find it correct.

T. B. SPRAGUE.

4th Dec. 1891.

The following contribution to the Illustration Fund was announced :—

William Sanderson, £1 : 1 : 0.

Presents to the Library, Museum, and Herbarium at the Royal Botanic Garden were announced.

The CURATOR exhibited a flowering branch of *Posoqueria multiflora* from the Royal Botanic Garden.

The following Papers were read :—

EXCURSION OF THE SCOTTISH ALPINE BOTANICAL CLUB TO TYNDRUM IN 1891. By WILLIAM CRAIG, M.D., F.R.S.E., F.R.C.S. Ed., Secretary of the Club.

On Monday, 27th July 1891, the following members of the Scottish Alpine Botanical Club—viz., William B. Boyd, Rev. George Alison, Rev. David Paul, Dr A. P. Aitken, Mr G. H. Potts, and Dr William Craig assembled in Stewart's Royal Hotel, Tyndrum, Perthshire, for a few days' botanising. They were most comfortably entertained in the hotel, and the charges were very moderate.

Tuesday, 28th July.—This morning, after an early breakfast, the party drove in a waggonette abcut 8 miles down the valley of the Lochy on the way towards Dalmally, to a point near the foot of Beinn Laoigh. We ascended this mountain from its west side, and were soon at the rocks. The day was fine, and during our drive down the valley of the Lochy we saw two golden eagles.

We did not go to the top of the mountain, but confined our examination to the rocks on the west and north of the mountain. These rocks are very rich in alpine plants. We observed most of the common alpine plants, and amongst others, gathered *Dryas octopetala*, L.; *Saxifraga aizoides*, L.; *S. hypnoides*, L.; *S. nivalis*, L.; *S. oppositifolia*, L.; *S. stellaris*, L.; *Saussurea alpina*, DC.; *Bartsia alpina*, L.; in great abundance. *Juncus castaneus*, L.; *J. trifidus*, L.; *J. triglumis*, L.; *Carex atrata*, L.; *C. capillaris*, L.; *C. pauciflora*, Lightf.; *C. pulicaris*, L.; *C. pulla*, Good.; *C. rariflora*, Sm.; *C. rigida*, Good.; *Cystopteris montana*, Link., was seen in several ravines in great profusion.

In the evening we met our conveyance and returned to the hotel in good time for dinner, having enjoyed much our first day's excursion.

Wednesday, 29th July.—To-day we resolved to visit the eastern portion of Beinn Laoigh. We walked all the way from Tyndrum, going by Coninish, and reached the rocks immediately to the west of the Great Corrie. On the way up to the rocks we picked *Kobresia caricina*, Willd.; we did not go into the Great Corrie, but examined the rocks to the west of it. We saw most of the plants seen on the previous day, and again saw the *Cystopteris montana* in great profusion and beauty. To-day Mr Boyd gathered some good varieties of *Asplenium viride*, three of which he proposes to name:—1. *A. viride*, var. *bifidum*. This plant has all the fronds bifid. 2. *A. viride*, var. *truncatum*, and 3. *A. viride*, var. *convolutum*. Mr Boyd in a letter says, "If they keep as they are at present, they will be very distinct."

Rain came on in the afternoon, which somewhat spoiled our excursion and prevented us from going to the summit of the mountain. We returned to the hotel by way of Coninish. It rained the most of the way home, but this was the only rain we experienced during this excursion.

Thursday, 30th July.—We resolved to-day to examine some of the places near Tyndrum. Accordingly we first examined the rocks in Crom Allt, a small burn which comes down from Beinn Odhar. The burn forms a beautiful ravine, in which were many sub-alpine plants and some good mosses, but none deserving any special notice.

We afterwards visited Lochan Bhe, a small loch to the

north-west of Tyndrum, and from which the Lochy takes its rise. It is situated in Argyleshire, and is 822 feet above sea-level. In this loch we saw some good aquatic plants, such as *Lobelia Dortmanna*, L.; *Sparganium natans*, L.; and *Isoetes lacustris*, L. We gathered in considerable quantity a grass-like plant, growing entirely under water, and at a considerable distance from the edge of the loch, which we were unable to identify. Living specimens were obtained, and the plant is now being cultivated in the Royal Botanic Garden. The plant has been submitted to various authorities, including Mr Bennett of Croydon, and there appears to be a general consensus of opinion that the plant is *Scirpus fluitans*, L. I asked Dr John H. Wilson to examine the plant microscopically, and he writes to me saying "further microscopic examination has convinced me that your Tyndrum plant is *Scirpus fluitans*." There was neither flower nor fruit on any of the specimens gathered. The leaves were long, linear, and grass-like, and the plant presented somewhat the appearance of having become viviparous, producing new plants instead of flowers. I sincerely hope the plant will produce flowers in the Royal Botanic Garden, and thus establish beyond the possibility of a doubt the identity of the species. We could see no vestige of *Scirpus fluitans* growing around the edge of the loch, and certainly if it be *S. fluitans* it is a very remarkable variety. Hooker gives the length of the leaves of *S. fluitans* as 1 to 2 inches, and Bentham as $\frac{1}{2}$ to 2 inches. The leaves on our plants were very much longer. *Scirpus fluitans* is not a common plant, and our plant was abundant in the loch. Babington, in his Manual, mentions under *Scirpus fluitans* "stem rooting from the lower joinings and spreading to a great extent in a zigzag manner." This may to a certain extent explain one of the peculiarities of our plant. I hope that a further search will be made in Lochan Bhe for this plant. In many respects this was not only, the find of the day, but was the best plant gathered during this excursion.

Friday, 31st July.—To-day we resolved to visit the Corrie in Cruach Ardran, a mountain 3428 feet high, and situated south-west of Ben More. We took the train from Tyndrum to Crianlarich, from which the mountain is easily ascended. The day was fine, and we had a pleasant excursion. The

best rocks in the Corrie are on the right hand as we ascend the burn. On these rocks we saw many of the common alpine plants, including *Draba incana*, L.; and *Hymenophyllum unilaterale*, Willd. We ascended to the summit by the south ridge, and on the ridge saw *Potentilla Sibbaldi*, Hall. f.; *Silene acaulis*, L.; *Gnaphalium supinum*, L.; &c. From the summit we obtained a splendid view: we saw Loch Voil and Loch Lomond, and had a good view of the surrounding mountains. On the rocks at the summit we gathered many good plants, including *Saxifraga nivalis*, L.

By far the best botanising ground on this mountain is among the debris in the ravine leading from the summit north-east towards Am Binnein. On this portion of the mountain we found such plants as *Cerastium alpinum*, L.; *Cochlearia alpina*, Wats.; *Armeria vulgaris*, Willd.; *Epilobium alpinum*, L.; *Silene acaulis*, L.; *Saxifraga nivalis*, L.; and other species.

On returning to Crianlarich we learned that the train was nearly two hours late. We therefore drove to Tyndrum in a waggonette, and reached the hotel in good time for dinner, after a very pleasant though not a very productive excursion, but an excursion to a mountain which was new ground to the Club, and one about which we previously knew nothing.

This may be said to have ended our excursion, for on Saturday the meetings of the Club were brought to a close, and all the members returned home except Mr Potts, who remained behind for a few days' fishing.

Appended is a list of the principal plants collected during our four days' excursion to Tyndrum:—

Thalictrum alpinum, L.; Ranunculaceæ.
Trollius europæus, L.; ,,
Arabis petræa, Lamk.; Cruciferæ.
Draba incana, L.; ,,
Cochlearia alpina, Wats.; ,,
Silene acaulis, L.; Caryophylleæ.
Cerastium alpinum, L.; ,,
Arenaria Cherleri, Benth.; ,,
Rubus Chamæmorus, L.; Rosaceæ.
,, saxatilis, L.; ,,
Dryas octopetala, L.; ,,
Potentilla Sibbaldi, Hall. f.; ,,
Alchemilla alpina, L.; ,,
Saxifraga oppositifolia, L.; Saxifrageæ.
,, nivalis, L.; ,,
,, stellaris, L.; ,,
,, aizoides, L.; ,,
,, hypnoides, L.; ,,
Drosera anglica, Huds.; Droseraceæ.
Epilobium alpinum, L.; Onagrarieæ.
Adoxa Moschatellina, L.; Caprifoliaceæ.
Galium boreale, L.; Rubiaceæ.
Gnaphalium supinum, L.; Compositæ.
Saussurea alpina, DC.; ,,
Cnicus heterophyllus, Willd.; ,,
Lobelia Dortmanna, L.; Campanulaceæ.
Vaccinium uliginosum, L.; Ericaceæ.
,, Vittis-Idæa, L.; ,,
Pyrola rotundifolia, L.; ,,
Armeria vulgaris, Willd.; Plumbagineæ.
Lysimachia Nummularia, L.; Primulaceæ.
Bartsia alpina, L.; Scrophularineæ.
Oxyria digyna, Hill.; Polygonaceæ.
Salix herbacea, L.; Salicineæ.
Habenaria viridis, Br.; Orchideæ.
Tofieldia palustris, Huds.; Liliaceæ.
Juncus triglumis, L.; Junceæ.

Juncus castaneus, L.; Junceæ.
,, trifidus, L.; ,,
Luzula spicata, DC.; ,,
Sparganium natans, L.; Typhaceæ.
Kobresia caricina, Willd.; Cyperaceæ.
Carex pauciflora, Lightf.; ,,
,, pulicaris, L.; ,,
,, atrata, L.; ,,
,, rigida, Good.; ,,
,, rariflora, Sm.; ,,
,, capillaris, L.; ,,
,, pulla, Good.; ,,
Poa glauca, Sm.; Gramineæ.
Hymenophyllum unilaterale, Willd.; Filices.
Asplenium Ruta-muraria, L.; Filices.
Asplenium Trichomanes, L.; Filices.
,, viride, Huds.; ,,
,, Adiantum-nigrum, L.; ,,
Cystopteris montana, Link.; ,,
Aspidium Lonchitis, Sw.; ,,
,, aculeatum, Sw.; ,,
Nephrodium Oreopteris, Desv.; ,,
Polypodium alpestre, Hoppe; ,,
Lycopodium alpinum, L.; Lycopodiaceæ.
Lycopodium Selago, L.; Lycopodiaceæ.
Isoetes lacustris, L.; Selaginellaceæ.

To this list I may add

Scirpus fluitans, L., var.

The Scottish Alpine Botanical Club was founded in 1870, twenty-one years ago, so we have now reached our majority—and during these twenty-one years we have made annual excursions, and with three exceptions, these excursions have been to the Highlands of Scotland. The three exceptions being—to Teesdale and Kirkby Lonsdale in England in 1884; to the Hardanger District of Norway in 1887; and to Connemara in Ireland in 1890.

These annual excursions have afforded much happiness and pleasant intercourse to the members of the Club, and in addition, have contributed not a little to our knowledge of the flora of Scotland. Among the most notable discoveries made by the Club during these excursions may be mentioned the discovery of *Gentiana nivalis*, L., in Chamacreag, by Professor Bayley Balfour on 3d October 1872; the discovery of *Carex frigida* (Allioni), a plant new to the British Isles, in Corrie Ceann-mor, and of *Salix Sadleri* (Syme), a plant new to science, both plants being discovered in the same Corrie by the late Mr John Sadler on 7th August 1874. On 31st July 1880 the Club discovered a new station for *Thlaspi alpestre*, L., in Glen Taitneach, near Spittal of Glen Shee. It is probable that it was during the excursion of the Club to Braemar in 1883 that Mr Boyd gathered that remarkable *Sagina* which bears his name. On 4th August 1885 I gathered on Ben Laoigh three plants of *Aspidium Lonchitis* with every frond crested. During our excursion to Glen Spean in 1886 Mr Boyd discovered a new station for that rarest of Scottish plants *Saxifraga cæspitosa*, L., and which I believe to be the only known station for this plant in this country. During the same excursion we discovered two new stations for *Saxifraga rivularis*, L., and one for

Luzula arcuata, Swartz. And during our excursion to Connemara, Dr Stuart discovered the heath which bears his name, a variety never previously described in so far as known to the members of the Club. All these were original discoveries, and deserve a permanent place in the records of Botanical Science.

In conclusion, I think it right to mention that at the business meeting of the Club reference was made to the great loss the Club had sustained since its previous meeting by the death of Mr Archibald Gibson, one of the original members of the Club. Mr Gibson had on several occasions granted privileges to the Club, which in his official capacity as Secretary to the Caledonian Railway he was enabled to do. He was, moreover, a man of a most genial disposition, and was universally beloved by all who knew him. His death is a great loss to the Club, and has left a blank which it will be difficult to fill.

The roots of Grasses in relation to their upper growth. By Andrew P. Aitken, D.Sc., F.R.S.E., Professor of Chemistry, Royal (Dick) Veterinary College, Edinburgh.

(With Plates II. and III.)

During recent years, when the agriculture of this country has been passing through a period of great depression, the minds of farmers have been much exercised in endeavouring to discover how they can best utilise the resources of their soil, so as to contend successfully against the greatly increased foreign competition to which they are now subjected. One of the chief directions in which it has been found possible to make a great and safe advance is in the improvement of grass land. As the result of many experiments and observations, it was found that many of the grasses grown on meadow land were of very inferior quality, that much that farmers included under the term grass was simply weeds, and that while many of these were nature-planted, not a few were imported in the seeds sown upon the farm. Farmers are now becoming educated in these matters, and they are now demanding and they are also able to obtain grass seeds fairly pure and true to name. A good deal has been done by way of determining by means of analysis what are the

species of grass that are most nutritious, and experiments are now in progress to discover what are the best proportions in which various seeds should be sown so as most completely to occupy the ground and leave least room for weeds taking possession of the soil. The management and manurial treatment of grass so as to favour the best species and discourage others is also receiving attention; and inasmuch as the answers to these questions will vary according to the nature of the soil and climate, the purpose for which the grass is grown, the number of years it is to be allowed to lie, and many other considerations, it is evident that the subject of grass cultivation is a very wide one, and only to a very limited extent appropriate for discussion in this Society.

It seemed to me an important thing, from an agricultural point of view, to study the rooting of grasses more carefully than has been the custom hitherto, and I began an experiment the summer before last with a simple object in view, viz., to discover what proportion the underground structure bore to the overground structure of the more important grasses, to see what was the special characters of their roots, and, further, to see what part of the soil the various species utilised in their search for nourishment.

These questions have an important bearing upon agricultural practice, for grasses are grown not only for the sake of the food contained in their leaves and stems, but also for the sake of the manurial value of their roots. In some cases it is mainly for the sake of the amelioration of the soil that land is laid down in grass, to "rest" as it is called. After it has so rested for some years it is once more put under the plough, and the accumulation of organic matter due to the growth of grass roots provides suitable soil and nourishment for the cereal crops which follow. Accordingly it is of importance to know what are the grasses which make the greatest amount of root growth in proportion to their amount of leafage. On the other hand, where a soil is thin and a hay crop is wanted, it is of service to know what are the species of grass which yield the largest crop of hay with the smallest demand for soil space.

Another important object to be attained by a more thorough knowledge of the rooting of grasses is the more complete utilisation of all the available area of the soil. It

is not unusual to find land lying in grass where only the upper layer of the soil is charged with roots to any notable extent, while the lower layers are lying idle for want of the presence of those grasses which send their roots down into the lower soil and subsoil. The farmer will probably be heard complaining that his land is too dear, and yet he may be found utilising only the upper half of it. By the selection in due proportion of grass seeds of different rooting tendencies, it is natural to suppose that the capabilities of grass land might be greatly increased. It was such considerations that led me to make the experiment I have to bring before your notice.

There are some difficulties in the way of making such an experiment, but the chief one is that of collecting the grass roots in such a way as to lose nothing—not even the smallest hairs. To get over that difficulty, I had a number of pots made of zinc, like the one I now exhibit. It is 2 feet deep, with a superficial soil area of 6 inches square. One side of the box is made movable, so that it can be taken off and put on at pleasure. The pots or rather boxes were filled almost to the top with good farm soil made thoroughly homogeneous and well shaken down, and between the movable side and the soil there was placed a sheet of glass to enable me to take off the side without disturbing the soil, and this I did in the hope that I might be able to see the roots and watch their progress. The mass of roots which one sees sometimes when repotting plants led me to expect that the grass roots might be in part visible, but in this I was entirely disappointed—there was scarcely a trace of a root to be seen at any time during the period of growth. The zinc boxes were all sunk in sawdust in a large square wooden box which was turned every morning one quarter round, so as to expose all the pots equally to the light, &c., and give them all an equal chance.

The seeds were sown in June 1889, and the crop was cut and the roots were taken out in end of June 1890, so that the quantities of vegetable matter produced represent only the first year's growth.

In taking the plants out of the earth each box was laid on its back, the movable side and the glass below it taken away, and the whole was immersed in water in a large sink

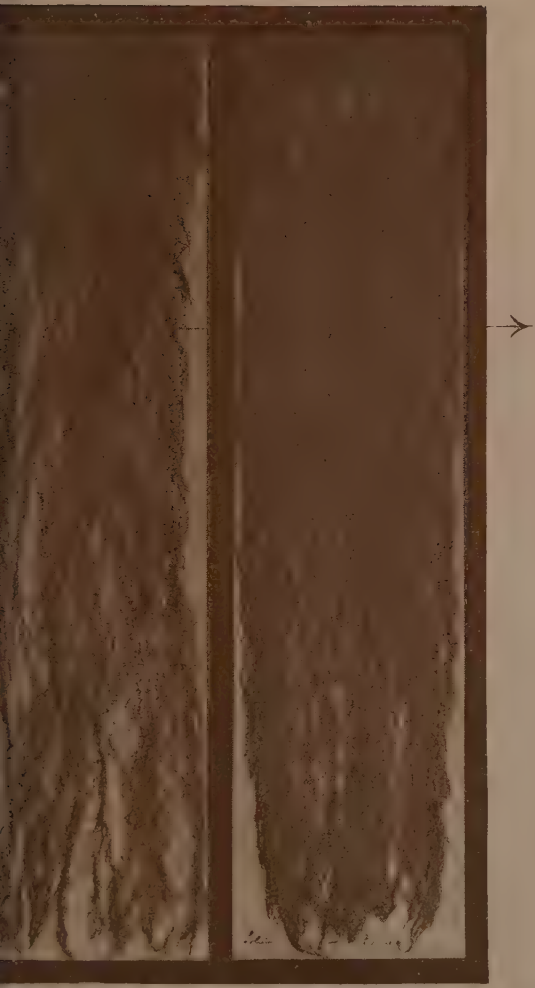
and placed on a wire grating, which was supported some inches above the bottom of the sink.

On this grating the block of earth was carefully placed by canting the box slowly over on its face, and the particles of earth gradually fell away from the roots, and passed through the grating, leaving the roots almost *in situ* and quite uninjured. The roots were removed to another sink full of clean water to get rid of their last traces of soil, and then floated out upon zinc plates 6 inches broad, in the same way as sea-weeds are managed, and there they were allowed to dry. I have since transferred them to white paper, where they are better seen, and as you see I have gummed them down. Before doing so I cut the roots away from the stubbles, which were weighed separately, and the roots also were cut at a depth of 8 inches from the stubbles, and the two portions of root, namely the upper 8 inches and the lower 16 inches, were separately weighed. All these portions, the grass, the stubble, and the two sections of roots, were weighed in an air-dry condition some months after their removal from the boxes, and the actual weighings of the produce from a block of soil 6 inches square and 2 feet deep, viz. half a cubic foot in content, are given in the adjoining table.

TABLE I.—Weight of Produce of Grasses in Grammes.

	Upper Growth.		Root.		Total.	
	Hay.	Stubble.	Upper Third 8 inches.	Lower Two-Thirds 16 inches.	Upper Growth.	Roots.
1. Lolium perenne, L. (28 lb. per bushel), (Perennial Rye Grass),	24·15	4·70	3·96	4·26	28·85	8·22
2. Festuca elatior, Auct. (Tall Fescue),	20·85	6·92	4·60	2·60	27·77	7·20
3. Avena flavescens, L. (Golden Oat Grass),	15·50	3·40	4·95	1·67	18·90	6·62
4. Dactylis glomerata, L. (Cock's Foot),	13·75	16·71	4·65	1·45	30·46	6·10
5. Alopecurus pratensis, L. (Meadow Fox Tail),	11·75	2·54	3·87	1·62	14·29	5·49
6. Festuca pratensis, Huds. (Meadow Fescue),	10·85	4·68	3·07	2·05	15·53	5·12
7. Lolium perenne, L. (22 lb. per bushel),	10·75	6·99	2·60	1·40	12·72	4·00
8. Cynosurus cristatus, L. (Dog's Tail),	12·00	6·18	3·20	0·71	18·18	3·91
9. Phleum pratense, L. (Timothy),	11·70	4·70	1·90	0·82	16·40	2·72
10. Poa pratensis, L. (Smooth Meadow Grass),	14·45	5·20	1·84	0·79	19·65	2·63
11. Poa trivialis, L. (Rough ,, ,,),	19·50	4·96	2·30	0·31	24·46	2·61
12. Poa nemoralis, L. (Wood. ,, ,,),	13·25	2·50	1·80	0·27	15·75	2·07
13. Anthoxanthum odoratum, L. (Sweet Vernal Grass),	12·90	1·47	0·92	0·19	14·37	1·11
14. Festuca ovina, L. (Sheep's Fescue),	3·65	1·10	0·70	0·05	4·75	0·75

The grasses are here arranged in order according to the weight of root material they produced.

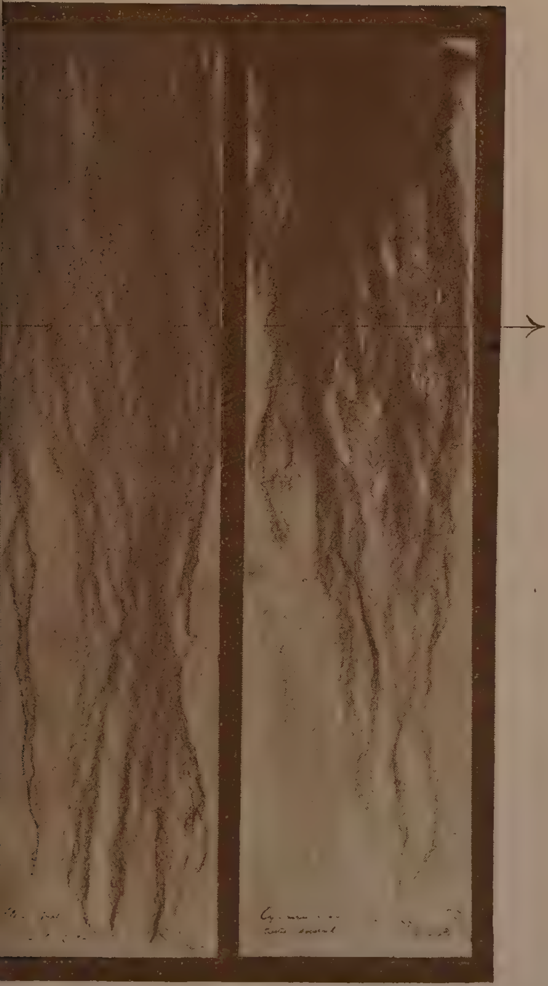


Festuca elatior.

Lolium perenne
(28 lb. per bushel).

e left with Table I.

9 9 8 7



Phleum pratense. Cynosurus cristatus

he left with Table I.

It is not to be supposed that these figures represent accurately the relative weights of produce which the respective grasses may be expected always to yield, for, as experience abundantly shows, the vigour of a species of grass depends in the first place on the goodness of the seed, for weak parents produce weak offspring, and also on the nature of the soil and climate and other circumstances. These grasses were grown in a greenhouse attached to my laboratory, in light loamy soil, and the seed was the best procurable that year, while the quantity sown was such as to sufficiently occupy the surface area of 36 square inches.

Upon the whole, I am of opinion that the quantities of product are fairly representative of what the respective grasses may, under favourable circumstances, be expected to grow in one year.

As might be expected, the perennial rye-grass of the best quality, 28 lb. per bushel, tops the list in quantity both of leaf and root, but there is another specimen of root from rye-grass of 22 lb. per bushel, and it is instructive to notice how great is the difference between this fine sample of rye-grass whose seed weighed 28 lb. per bushel, and the inferior sample whose seed weighed only 22 lb. per bushel, accentuating the great importance of selecting the best seed, of the false economy of endeavouring to make a saving by purchasing seed of inferior quality. Next comes the tall fescue, which approaches it very nearly. It is a grass which is not very well known to farmers, but it is evidently one which they ought to value very highly.

The golden oat-grass has produced the most unexpected result, for it is usually regarded as one of the feeble grasses, although known to be a good pasture grass. It is evident from this experiment that it deserves a higher place in the esteem of farmers than has been hitherto accorded to it, and that it may well take a place among the seeds of grass that is intended to lie even for one year.

Cocksfoot, foxtail, and timothy, which are the great bulky natural grasses of the farm, take a subordinate place in the table, the last named more especially in regard to the quantity of roots produced; but it is necessary to remember that these grasses do not make much growth during the first year, but go on steadily improving for several years.

The poas are seen to be poor rooting grasses. But it is to the proportion between the upper and under growth that I wish chiefly to direct your attention.

TABLE II.—Proportion of Grass and Roots per cent.

	Upper Growth.		Root.		Total.	
	Hay.	Stubble.	Upper Third.	Lower Two-Thirds.	Grass.	Root.
1. Alopecurus pratensis,	59·4	12·8	19·6	8·2	72·2	27·8
2. Avena flavescens,	60·8	13·3	19·4	6·5	74·1	25·9
3. Festuca pratensis,	52·5	22·7	14·8	10·0	75·2	24·8
4. Lolium perenne (22 lb. per bushel),	64·3	11·8	15·6	8·3	76·1	23·9
5. Lolium perenne (28 lb. per bushel),	65·1	12·7	10·7	11·5	77·8	22·2
6. Festuca elatior,	59·7	19·8	13·2	7·3	79·5	20·5
7. Cynosurus cristatus,	54·3	28·0	14·5	3·2	82·3	17·7
8. Dactylis glomerata,	37·6	45·7	12·7	4·0	83·3	16·7
9. Phleum pratense,	61·2	24·6	9·9	4·3	85·8	14·2
10. Festuca ovina,	66·4	20·0	12·7	0·9	86·4	13·6
11. Poa pratensis,	64·9	23·3	8·2	3·6	88·2	11·8
12. Poa nemoralis,	74·4	14·0	10·1	1·5	88·4	11·6
13. Poa trivialis,	72·1	18·3	8·5	1·1	90·4	9·6
14. Anthoxanthum odoratum,	83·4	9·5	5·9	1·2	92·9	7·1

That is a character less under the influence of external or accidental circumstances. The bulk of the crop of grass may be large or small, according to circumstances; but it may be presumed that the relative proportion of that which is above and below ground will be pretty constant, inasmuch as that is a circumstance depending chiefly on the nature and habit of the plant.

If I am right in that assumption, then the results of this experiment (as shown in Table II.) convey information of considerable value to agriculturists, for it shows that the foxtail (*Alopecurus pratensis*), the golden oat-grass (*Avena flavescens*), and the common meadow fescue (*Festuca pratensis*), are even better than rye-grass in respect of the proportion of root matter which they contribute to the soil after one year's growth. Of these three grasses the first is a much prized early grass, the second is apt to be overlooked, and the third is regarded with disfavour by some on account of the hardness of its leaf.

The poas, which are a much esteemed class of grasses, are seen to be among the least valuable of the grasses in so far as rooting power is concerned. As to the sweet vernal grass (*Anthoxanthum odoratum*), it is seen to be the feeblest rooter among the grasses.

The depth to which the roots penetrate in search of food is fairly well shown by the two columns indicating the amounts of root matter above and below the 8-inch limit.

Pre-eminent among deep-rooting grasses is rye-grass, which has more than half of its roots below the 8-inch layer. This is one of the most valuable characteristics of that grass. In the short period of one year its roots are able to penetrate to the subsoil, and bring up to the surface the stores of plant food contained there, some of which would otherwise be lost to the soil.

That this is the habit of the species is seen by the fact that the two samples of rye-grass resemble each other in that respect, although differing so widely in quality.

Next in value in this respect is the meadow fescue, nearly the half of whose roots dip below 8 inches, and then the tall fescue, fully one-third of whose roots are in the lower soil and subsoil. Even the common meadow-grass (*Poa pratensis*) has more than one-fourth of its roots in the lower soil, and in that respect it is a serviceable grass, but the other poas have a very feeble hold upon the subsoil, and belong to that class of grasses which are easily injured by extremes of heat and cold.

As to the sweet vernal grass (*Anthoxanthum odoratum*), it is seen to be a merely surface grass, finding with difficulty its nourishment in that part of the soil where it is subjected to the greatest competition from its stronger rivals. Fortunately it is not a grass that it is desirable to have in a pasture except to a very limited extent—more as a flavouring ingredient than as any considerable component of the grass or hay.

The specimens of the actual roots that are before you tell their story more eloquently than the diagrams, but not so accurately, as the eye cannot do more than examine their surface. The roots are gummed on to strips of paper exactly the width of the box in which they were grown. You will see that they are there in their entirety, and as nearly *in situ* as it is possible for that which is grown in three dimensional space to be when it is flattened down into a space of two dimensions.

In conclusion, I would again remind you that these observations are made upon grass of one year old. A set of

two-year-old roots would doubtless present a very different picture, and I trust I may be able to exhibit such a one by and by to the Society.

NOTES ON THE FLORA OF THE MOFFAT DISTRICT FOR 1891.

By JOHN THORBURN JOHNSTONE, Moffat.

I. New records for the County of Dumfries gathered in this district:—

Fumaria confusa, Jord., July 11. Waste ground, Beattock station.

Fumaria densiflora, DC., Aug. 1890. Edgemoor, in Parish of Johnstone, but was named by Mr A. Bennett in 1891.

Stellaria umbrosa, Opiz., Aug. 22. Linn at Cleughfoot (foliage only).

Hypericum perforatum, var. *angustifolium*, Gaud., Aug. 12. Wamphray Glen.

Hypericum perforatum, var. *lineolatum*, Jord., Aug. 15. Barnhill Road.

Medicago lupulina, Linn., July 11. Waste ground, Beattock station, gathered by Mr James M'Andrew.

Epilobium montanum, Linn., var. *minus*. Black's Hope. This plant was also gathered here two seasons ago by Mr E. F. Linton.

Hieracium gothicum, Fr., July 26. Well Burn.

Vaccinium uliginosum, Linn., Aug. 29. Moffat Hills, elevation from 1800 to 2000 feet, growing on the mossy soil covering damp rocks.

Veronica serpyllifolia, Linn., var. *humifusa*, Dicks., July 19. Whitecoomb, elevation 2000 feet.

Euphrasia gracilis, Fr. Beattock Hill.

Polygonum lapathifolium, Linn., var. *incana*, July 4. Waste ground, Beattock station.

Polygonum Persicaria, Linn., sub sp. *nodosum*, Pers., var. *glandulosum*, August 5. Cornfield at Riddings Holm; name of plant determined by Mr A. Bennett, Croydon. And it is, as far as I am aware, a new record for Scotland.

Salix triandra, Linn., var. *Hoffmanniana* (Sm.). Annan Water.

Salix fragilis, Linn., var. *decipiens*, Hoffm. Barnhill Bridge.

Salix stipularis, Sm. Annan Water, at Oakridge side.

Salix Smithiana, Willd. Evan Water, at Holms Bridge.

Salix aurita × *phylicifolia*, Kerr.

Salix herbacea, Linn., var. *fruticosa*. Whitecoomb.

Luzula multiflora, Lej. Railway cuttings.

Carex glauca, Murr., var. *stictocarpa* (Sm.). Black's Hope.

Festuca loliacea, Huds. Waste ground at Gas Works, gathered by Mr James M'Andrew.

II. Plants which have been previously recorded for Dumfriesshire, but having hitherto no recorded habitat from this district:—

Papaver Rhœas, Linn. Waste ground, Beattock station.

Sisymbrium officinale, Scop. Waste ground near Industrial School.

Viola arvensis, Murr. Sandbeds and cultivated fields.

Hypericum hirsutum, Linn. Wamphray Glen.

Hippuris vulgaris, Linn. Earshaig Lakes.

Conium maculatum, Linn. Cornal Tower.

Apium nodiflorum, Reichb. Earshaig Burn.

Polygonum amphibium, Linn., var. *terrestre*, Leers. Waste ground, Beattock station.

Urtica urens, Linn. Nethermill.

Sparganium simplex, Huds. Earshaig Lakes.

Sparganium minimum, Fr. Earshaig Lakes.

Scirpus sylvaticus, Linn. Annan Water at Nether Murthat.

Scirpus multicaulis, Sm. Damp stony places on the hills.

Scirpus setaceus, Linn. Damp roadsides, &c.

Carex dioica, Linn. Frenchland Burn.

Carex ovalis, Good. Gallowhill, Frenchland Burn.

Carex Oederi, Ehrh. Hill ditches and damp places.

Phalaris arundinacea, Linn. Riversides.

Alopecurus geniculatus, Linn. Common.

Alopecurus pratensis, Linn. Common.

Holcus lanatus, Linn. Common.

Avena pratensis, Linn. Common.

Avena pratensis, Linn., var *alpina* (Sm.). Black's Hope and Hartfell.

Cynosurus cristatus, Linn. Common.

Dactylis glomerata, Linn. Common.

Poa pratensis, Linn. Common.

Glyceria fluitans, Linn. Common.

The following carices and grasses come under the above head, and were gathered by Mr M'Andrew, New Galloway, when staying at Moffat this summer:—

Carex hirta, Linn.; *C. paludosa*, Good.; *C. vesicaria*, Linn.; *Agrostis alba*, Linn.; *Aira caryophyllea*, Linn.; *Poa annua*, Linn.; *Festuca Myurus*, Linn.; *F. elatior*, Linn.; *Bromus giganteus*, Linn.; *B. mollis*, Linn.; *Agropyron caninum*, Beauv.

III. Plants not now found at their previous recorded stations, but which have been reconfirmed for the district:—

Cardamine impatiens, Linn., Aug. 22, near Kirkpatrick-Juxta Manse, where it rather curiously occurs as a wayside plant. Its former stations were at Garpel and Beld Craig Linn, but I have never come across it at these places. I also gathered this plant on the Mouse Water, near Cleghorn, on Aug. 23, 1890.

Vicia Orobus, DC., June 21, Beef Tub and Corehead; the previous station was the Grey Mare's Tail.

Arctostaphylos Uva-ursi, Spreng., Moffat Hills, Aug. 29 (foliage only). This, as far as Watson's Topographical Botany is concerned, is also a new record for Dumfriesshire, but it is given for the Moffat Hills in the Stat. Acct. Scot. for 1843.

Salix Lapponum, Linn., var. *arenaria* (Linn. ex p.), Whitecoomb.

IV. The following plants are already given for this district, but I have to report their occurrence in Lanarkshire (upper part of Crawford Parish), and all growing within two miles or so of the Dumfriesshire and Lanarkshire Boundary Line:—

Helianthemum Chamæcistus, Mill. Railway embankment past viaduct.

Silene Cucubalus, Willd. Railway embankment at viaduct.

Epilobium angustifolium, Linn. Rowan tree Grani Linn.

Conium maculatum, Linn. Around ruins of Crawford Castle.

Cnicus heterophyllus, Willd. Railway embankment Hampden's Bridge; meadows at Medlock; meadows at Watermeetings.

Hieracium gothicum, Fr. Small rivulet, not named on Ord. Map.

Hieracium auratum, Fr. Railway cutting near summit.

Hieracium strictum, Fr. Rowan tree Grani Linn.

Gentiana campestris. River embankments Medlock and Camps Water.

I have to express my indebtedness to Rev. E. F. Linton, Bournemouth, for naming the willows given in the foregoing list, and some of the other plants, and also to Mr A. Bennett, Croydon, for naming and examining the plants submitted to him.

On Temperature and Vegetation in the Royal Botanic Garden, Edinburgh, during November 1891. By Robert Lindsay, Curator of the Garden.

The past month of November, although somewhat changeable and unsettled, has been mild for the season. Storms of wind and rain were less frequent than usual, and no snow fell. The thermometer was at or below the freezing point on 12 mornings, indicating collectively 41° of frost for the month. The lowest readings were on the 18th, 28°; 23rd, 24°; 24th, 26°; 27th, 24°; 28th, 25°. The lowest day temperature was 38° on the 27th, and the highest 55° on the 2nd. Outdoor vegetation is, as nearly as possible, in a resting condition. Not a single plant came into flower on the Rock Garden during the month.

Readings of exposed Thermometers at the Rock Garden of the Royal Botanic Garden, Edinburgh, during November 1891.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	34°	44°	48°	16th	30°	31°	46°
2nd	44	45	55	17th	33	37	45
3rd	32	39	49	18th	28	35	52
4th	42	45	49	19th	34	44	47
5th	38	40	50	20th	43	45	50
6th	40	43	49	21st	32	37	46
7th	41	43	53	22nd	32	38	44
8th	37	39	47	23rd	24	25	43
9th	35	40	50	24th	26	35	43
10th	34	37	46	25th	29	38	42
11th	35	42	48	26th	32	38	42
12th	34	36	39	27th	24	26	38
13th	35	46	50	28th	25	35	45
14th	33	40	48	29th	37	40	44
15th	35	45	48	30th	29	35	47

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of November 1891.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass.				Direction of Wind.	Clouds.			Rainfall. (Inches.)
		S. R. Thermometers for preceding 24 hours.		Hygrometer.						
		Max.	Min.	Dry.	Wet.		Kind.	Amount.	Direction.	
		°	°	°	°					
1	30·608	47·0	32·1	47·0	47·0	N.E.	Nim.	10	N.E.	0·025
2	30·564	48·6	46·5	47·4	45·9	E.N.E.	Cum.	10	E.	0·000
3	30·475	51·8	35·3	40·0	39·8	S.E.	Cum.	10	S.E.	0·000
4	30·469	47·3	39·1	47·3	44·8	S.E.	Cum.	10	S.E.	0·025
5	30·610	48·0	40·6	47·2	46·0	E.	Cum.	10	E.	0·020
6	30·408	46·0	41·6	42·9	42·1	W.	Cum.	6	N.W.	0·000
7	30·262	47·4	42·2	45·0	44·1	S.W.	Cum.	4	S.W.	0·005
8	29·844	50·0	37·9	45·0	41·6	S.	Cum.	6	S.	0·030
9	29·246	46·9	39·0	42·1	40·3	S.W.	Cir.	2	W.	0·010
10	29·231	46·9	36·0	38·7	37·8	S.W.	...	0	...	0·190
11	28·569	44·9	37·1	44·9	44·0	E.	Nim.	10	E.	0·280
12	29·064	47·8	36·8	37·8	35·7	S.W.	...	0	...	0·005
13	29·038	48·4	37·0	48·3	46·1	E.	Nim.	10	S.E.	0·225
14	29·127	48·6	35·8	41·8	41·1	S.	Cum.	5	S.	0·010
15	29·354	45·9	39·0	45·5	44·8	E.	Cum.	8	.E	0·085
16	29·521	47·8	32·5	32·8	32·8	E.	...	0	...	0·075
17	29·533	45·1	32·3	41·2	40·9	S.	Nim.	10	S.	0·045
18	29·718	44·1	30·8	37·5	37·1	E.	Cum.	10	E.	0·324
19	29·528	52·9	36·8	46·3	43·9	S.W.	...	0	...	0·135
20	29·625	48·2	43·6	44·8	43·2	W.	Cum.	5	W.	0·005
21	29·779	46·9	35·1	38·1	37·8	Calm.	Cum.	9	N.E.	0·000
22	29·805	42·7	34·7	38·8	37·1	N.W.	Cum.	10	N.E.	0·000
23	29·753	41·9	26·0	27·1	27·0	Calm.	Fog.	10	...	0·000
24	29·778	35·5	26·1	35·5	35·5	N.W.	Cum.	10	W.	0·005
25	29·500	38·9	31·0	38·9	37·0	S.S.E.	Cum.	10	S.	0·000
26	29·430	40·9	30·2	33·4	33·0	S.W.	Cum.	4	S.W.	0·000
27	29·699	38·9	26·0	27·7	27·2	W.	...	0	...	0·000
28	29·514	36·0	26·1	36·0	34·7	S.E.	Cum.	10	S.S.E.	0·000
29	29·413	45·1	35·4	40·0	38·1	S.W.	...	0	...	0·010
30	29·559	42·7	31·6	35·2	34·8	S.	Cum.	10	S.W.	0·000

Barometer.—Highest Reading, on the 5th, =30·610. Lowest Reading, on the 11th, =28·569. Difference, or Monthly Range, =2·041. Mean=29·701.

S. R. Thermometers.—Highest Reading, on the 19th, =52°·9. Lowest Readings, on the 23rd and 27th, =26°·0. Difference, or Monthly Range, =26°·9. Mean of all the Highest=45°·4. Mean of all the Lowest=35°·1. Difference, or Mean Daily Range, =10°·3. Mean Temperature of Month=40°·2.

Hygrometer.—Mean of Dry Bulb=40°·5. Mean of Wet Bulb=39°·4.

Rainfall.—Number of Days on which Rain fell=19. Amount of Fall, in inches, =1·504.

A. D. RICHARDSON,
Observer.

On Temperature and Vegetation in the Botanic Garden, Glasgow, during November 1891. By Robert Bullen, Curator of the Garden.

This was another wet, variable, unseasonable month; much dark and foggy weather prevailed.

The maximum and minimum readings of the thermometer were both high for the season. No frost was registered until the night of the 21st, but after that, light night frosts were frequent. The lowest reading was 7° during the night of the 25th, and the total only 26°. Owing to the wet state of the ground, out-door work had to be abandoned.

The depression in girth-increase was evidently severe the first year after transplantation, and continued, although to a less extent, next year, but appeared to be at an end in 1889.

No. 90. *Retinospora obtusa.* Girth 3·05 inches 1 inch above ground in spring 1887; was transplanted in the following spring. No apparent effect on the healthy foliage.

	April.	May.	June.	First Half.	July.	Aug.	Sept.	Second Half.	Year.
1887	...	15	10	25	5	15	...	20	45
1888	...	...	...	...	10	10	...	20	20
1889	...	5	...	5	...	5	...	5	10
1890	...	...	...	...	10	...	...	10	10
1891	−5	15	...	10	5	5	...	10	20
Total,	−5	35	10	40	30	35	...	65	105

Although the shrub looks perfectly healthy and vigorous, yet the average rate of girth-increase for four years after transplantation has been only 0·15 inch, or one-third of the amount in the year before transplantation.

General Remarks. It is possible that the effects of transplantation in some of these instances were unusually unfavourable, as the early part of the season of 1887 was very dry. It is remarkable that although the falling off in girth-increase might generally be predicated from the poor condition of the foliage, yet in some instances there was no apparent relation of the kind between the two. Thus in *Abies Douglasii*, No. 66, although the foliage was exceedingly poor in 1889, and had not improved much in 1890, nevertheless the girth-increase in the former year sprang up from 0·45 of the previous depression to 1·20, and this rate was fully maintained in 1890—probably a normal rate for a tree of its age. Again, in *Retinospora obtusa,* No. 90, the foliage seemed absolutely unaffected by transplantation, but the girth-increase for four successive years has been reduced to an average of one-third of the rate in the year previous to transplantation.

A very shabby appearance in a tree even for some years after transplantation should not cause despair as to ultimate perfect recovery. Sir Robert Christison was informed by the elder Mr Macnab that the large Yew, now 6 feet in girth, and one of the chief ornaments of the Botanic Garden, took many years to recover from its third transplantation to its

present site; and my example, *Quercus rubra*, No. 61, proves that even after the total loss of the young wood of a season, a tree may rapidly recover perfect health.

ON A RAPID METHOD OF SHARPENING KNIVES FOR SECTION-CUTTING. By A. N. M'ALPINE, B.Sc.

A plane iron of the best quality is most suitable for my form of microtome. A rectangular strip of steel is fastened across the plane iron in such a way that the anterior edge of the rectangle is parallel to the edge to be sharpened. By this attachment, the plane iron is rendered virtually hollow ground and the sharpening is accordingly both rapid and true. When sharpening, the edge of the iron and the anterior margin of the steel band are ground together on the stone, and the edge is finished on a leather strop which ought to be fixed to a rigid support in order to prevent rounding.

Mr FORGAN asked leave of the Society to say that the device which Mr M'Alpine had brought before the Society was not a new one. It was referred to in Holtzappel's "Mechanical Manipulation" published at least forty years ago and might be then of very old date. Mr Forgan said he had used it himself more than thirty years ago when sharpening plane irons, to which it gave a very fine and equal edge. The statement in regard to it will be found in the second volume of Holtzappel, page 497, and is to the following effect: "When the minute chamfer of the plane iron is almost parallel with the sole of the plane, it will for a short time be entirely effective. Thus as an experiment, drive the iron a very small quantity through the sole, and sharpen it by allowing the oilstone to rub both on the edge and on the wood behind, this will produce a very accurate edge, and the iron when set back, will cut beautifully." The second volume of Holtzappel was published in 1846 by Holtzappel & Co., 64 Charing Cross and 127 Long Acre.

With reference to Mr M'Alpine's statement that he used a leather strop to fine the edge of the plane iron after it came from the hone, Mr Forgan pointed out that the same subject was discussed at the Royal Scottish Society of Arts about five years ago, when the late Dr Sang stated during the discussion that he never used a strop to improve the

edge of a razor after it had been sharpened on the hone, as he considered that the flexible strop had the effect of rounding the edge it had received from the hone and thus destroying its cutting power. Dr Sang said he invariably shaved with a razor straight from the hone, and did not use a strop for the above reason. Mr Forgan said he had followed this plan himself, and found that if due attention was paid to the one sharpening, no strop would improve the cutting edge. He showed to the meeting a very fine large hone which had been bought by his grandfather more than 100 years ago and was of excellent quality. These hones come from slate quarries near Ratisbon.

Mr M'ALPINE remarked that while for the purposes of shaving it might be possible to use a knife straight from the hone, for microtome sections it was necessary to use the strop after the hone.

Mr GUSTAV MANN pointed out that examination through the microscope of the edge of a razor straight from the hone showed a serrated edge which was fatal to microtome sections, especially if the "rocker-microtome" was used; the unevenness of edge must be removed by the strop before cutting fine sections.

ON GRAFTING FRUIT TREES FOR TRANSPORT. By JAMES GRIEVE.

The author exhibited specimens of grafted apples of a convenient size for transport by post. The stocks may be either two-year seedling crab or one-year Paradise cuttings, and are potted in the autumn into three-inch pots, and grafted in February or March under glass. The grafting wax used is composed as follows:—

Resin, . .	1 lb.	Tallow, .	$\frac{1}{2}$ lb.
Pitch, . .	1 lb.	Beeswax, .	$\frac{1}{4}$ lb.

The ingredients are melted together, and the composition is put on with a brush when in a warm liquid state. The quantity above mentioned should seal several hundreds of grafts. A plant one-year-old weighs not more than three or four ounces, and can therefore be transported at minimum cost.

Note on Some Recent Botanical Work. By Professor Bayley Balfour.

Professor Balfour gave an account of Treub's work on the Casuarineæ, and of Guignard's recent researches upon the nucleus.

On Temperature and Vegetation in the Royal Botanic Garden, Glasgow, during March 1892. By Robert Bullen, Curator of the Garden.

The spring month of March was in reality the winter of 1891–92. Frost and snow was in excess of anything we have experienced in the same month for many years, not even excepting March of last year which was an unusually cold month. Frost was registered on 23 nights, and the total registered for the month was 120°.

Night frosts were continuous for the first half of the month, and heavy snow fell during the second week; on the 16th a misty rain and thaw set in. On the night of the 19th, frost was again recorded and continued with more or less severity to the end of the month. The day temperature, especially during the latter half of the month, was above the average; hard frosty nights being succeeded by bright sunny days. The sun thermometer frequently registering from 70° to 76°. Very dry weather prevailed after the heavy snow fall. All vegetation is much retarded.

On Temperature and Vegetation at the Royal Botanic Garden, during March 1892. By Robert Lindsay, Curator of the Garden.

The past month has been exceedingly wintry with much snow and frequent frost, which proved a great hindrance to the progress of vegetation. The thermometer was at or below the freezing point on twenty-six occasions, indicating collectively for the month, 156° of frost as against 130° for the corresponding month last year.

The lowest readings occurred on the 6th, 22°; 15th, 20°; 16th, 20°; 28th, 16°; 29th, 17°. The lowest day temperature was 37° on the 27th, and the highest 64° on the 31st.

It is evident that many plants have suffered severely

during this long and trying winter, but the full extent of the damage done will not be known till later on in the season. Among those killed or very badly injured, are the following plants which have stood unprotected for several years past, viz.:—*Cordyline australis*, *Edwardsia microphylla*, *Olearia macrodonta*, *O. Gunniana*, *Phormium tenax*, *Benthamia fragifera*, *Leptospermum Scoparium*, *Myrsine undulata*, *Corokia Cotoneaster*, *Phlomis fruticosa*, *Eucalyptus coccifera*.

The following spring-flowering plants annually recorded to the Society, came into flower in March: *Tussilago nivea* on the 2nd; *T. alba*, 4th; *Iris reticulata*, 17th; *Nordmanica cordifolia*, 20th; *Scilla bifolia*, 19th; *S. bifolia alba*, 20th; *S. bifolia taurica*, 22nd; *Arabis albida*, 22nd; *Erythronium Dens-canis*, 23rd; *Sisyrinchium grandiflorum*, 23rd; *S. grandiflorum album*, 23rd; *Mandragora officinalis*, 24th; *Narcissus pumilus*, 27th; *Orobus vernus*, 30th; *Rhododendron Nobleanum*, 30th; *Ribes sanguineum*, 31st.

On the rock-garden 39 species and varieties came into flower during the month. The most interesting were—*Corbularia nivalis*, *Chionodoxa Lucillæ*, *Crocus Sieberi*, *C. etruscus*, *Corydalis angustifolia*, *Draba Aizoon*, *Iris reticulata*, *Mandragora vernalis*, *Ranunculus anemonoides*, *Saxifraga media*, *S. juniperina*, *S. lutea purpurea*, *Synthiris reniformis*, *Veronica anomala*.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during March 1892.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	32°	35°	42°	17th	39°	49°	55°
2nd	31	32	38	18th	46	47	59
3rd	29	31	38	19th	34	49	61
4th	28	31	40	20th	32	46	60
5th	29	31	43	21st	26	42	52
6th	22	24	40	22nd	26	33	46
7th	29	31	40	23rd	30	40	56
8th	30	31	45	24th	39	45	60
9th	24	27	40	25th	31	44	56
10th	24	30	39	26th	35	40	49
11th	25	31	42	27th	24	32	37
12th	25	30	43	28th	16	35	45
13th	26	32	37	29th	17	35	45
14th	25	30	48	30th	24	38	55
15th	20	26	45	31st	30	44	64
16th	20	25	49				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of March 1892.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	30·082	41·2	34·5	37·1	34·1	E.	Cum.	10	N.E.	0·000
2	30·274	40·0	33·1	34·5	31·6	E.	Cum.	10	E.	0·000
3	30·351	35·4	31·1	32·7	31·1	E.	Cum.	10	E.	0·000
4	30·362	34·8	30·3	32·8	31·2	S.	Cum.	10	S.E.	0·000
5	30·318	36·9	31·1	33·9	31·9	S.W.	Cum.	10	S.W.	0·000
6	30·159	38·4	25·7	30·5	29·5	W.	...	0	...	0·000
7	29·969	37·7	29·9	33·2	31·1	S.	Cum.	10	S.	0·000
8	29·801	37·7	30·2	34·2	32·0	W.	Cum.	9	W.	0·010
9	29·383	42·5	25·1	29·5	26·9	N.W.	Cum.	2	N.	0·080
10	29·324	34·9	26·5	30·9	29·2	N.	...	0	...	0·175
11	29·626	36·9	28·1	31·2	31·1	N.N.W.	Cum.	6	N.N.E.	0·175
12	29·574	40·8	29·0	32·0	29·8	N.N.E.	Cum.	4	N.N.E.	0·145
13	29·322	38·6	31·6	32·8	32·0	N.	Cum.	5	N.E.	0·045
14	29·326	36·8	26·8	33·7	31·7	W.	Cum.	6	N.	0·000
15	29·352	41·2	21·3	28·4	27·5	Calm	...	0	...	0·000
16	29·703	39·9	23·5	26·5	25·9	Calm	...	0	...	0·000
17	29·667	51·2	26·0	49·9	46·8	S.S.W.	Cum.	8	S.S.W.	0·000
18	30·076	55·3	47·9	51·2	49·0	S.W.	Cum.	10	S.W.	0·000
19	30·215	60·6	37·2	46·2	41·5	S.E.	...	0	...	0·000
20	30·244	58·7	35·0	40·8	38·1	E.S.E.	Cum.	5	E.S.E.	0·000
21	30·244	48·8	28·8	34·1	33·0	N.W.	...	0	...	0·025
22	30·520	43·9	36·3	42·1	38·4	W.	...	0	...	0·085
23	30·444	49·8	38·4	47·3	45·0	W.	...	0	...	0·000
24	30·174	56·0	34·7	44·9	42·2	W.	...	0	...	0·000
25	29·859	51·8	39·0	43·8	41·1	W.	Cum.	10	W.	0·000
26	29·489	46·2	38·0	45·9	43·0	W.	Cum.	10	W.	0·390
27	29·878	46·5	26·1	29·8	28·0	N.E.	Cum.	5	N.W.	0·020
28	29·917	34·0	19·2	33·8	30·4	W.	...	0	...	0·025
29	30·433	40·6	20·8	32·5	28·4	W.	...	0	...	0·000
30	30·488	41·7	28·1	40·4	36·9	W.	Cir.	2	N.	0·000
31	30·415	51·3	33·2	46·5	40·1	W.	Cir.	2	W.	0·000

Barometer.—Highest Reading, on the 22d, =30·520. Lowest Reading, on the 13th, =29·322. Difference, or Monthly Range, =1·198. Mean=29·967.

S. R. Thermometers.—Highest Reading, on the 19th, =60°·6. Lowest Reading, on the 28th, =19°·2. Difference, or Monthly Range, =41°·4. Mean of all the Highest=43°·5. Mean of all the Lowest=31°·2. Difference, or Mean Daily Range, =12°·3. Mean Temperature of Month=37°·4.

Hygrometer.—Mean of Dry Bulb=36°·9. Mean of Wet Bulb=34°·5.

Rainfall.—Number of Days on which Rain, or Snow, fell=11. Amount of Fall, in inches, =1·175.

A. D. RICHARDSON,
Observer.

THE EMBRYO-SAC OF MYOSURUS MINIMUS, L.: A CELL STUDY.[1] By GUSTAV MANN.

(With Plates III*a* and IV.)

(Read at the Meeting of the Society on January 28, 1892.)

In a previous paper* a short account was given of some facts which seemed to me to disprove the view generally held that the embryo-sac of Angiosperms is a macrospore. As several treatises on the same subject have since then come to my hand, and as I have made out some further interesting points in the structure of nuclei and nucleoli, a detailed account of my researches, accompanied by illustrations, may, I hope, prove to be of service to all who consider the study of cells the surest way of gaining an insight into the great problem of Life.

The methods employed in my investigation were shortly these: Flowers in all stages of development were fixed and hardened in my picro-corrosive-alcohol,† this fluid being very gradually replaced by pure absolute alcohol, by chloroform and ultimately by paraffin. Great care was taken to raise the flowers gradually to the temperature of melted paraffin (50° C.), and not to leave them longer at this temperature than was absolutely necessary for perfect imbedding. Finally the paraffin was allowed to cool gradually.

For sectioning I have used the Cambridge rocking-microtome, the feed consisting for ordinary work of two teeth (thickness of sections equal to 1·27 μ or $\frac{1}{20,000}$ of an inch), but whenever a doubtful point arose the feed was made to consist of only one tooth (thickness of section equal to ·635 μ or $\frac{1}{40,000}$ of an inch). The sections were fixed serially by means of Schällibaum's fixative on ordinary microscopic slides, or for special investigation on No. 1 cover-glasses ($1\frac{1}{2} \times 3$ inches). The mounting on thin cover-glasses has the advantage of allowing one to study the sections from two sides.

As staining reagents I have used with preference Kleinenberg's hæmatoxylin No. 1 with 20 p.c. of absolute

* Trans. Bot. Soc. Edin., vol. xix. (June 1891) p. 136. See also Trans. Bot. Soc., xix. pp. 67 and 89.

† Trans. Bot. Soc., vol. xviii. p. 432.

[1] Received for publication April 1892. Issued July 1892.

alcohol superadded to avoid as much as possible the hydration with the subsequent dehydration of tissues; for I find that sections treated with watery stains show when mounted in balsam, a shrinkage of delicate structures which is absent if aniline dyes dissolved in absolute alcohol are used as staining reagents, and which is very slight if reagents be employed containing a high percentage of alcohol. To obtain good results with Kleinenberg's hæmatoxylin, place glass-slides with the serial sections in a vessel containing the dye, and keep the vessel for twelve hours at a temperature of 30° C., then remove the slides to a second vessel containing a saturated solution of bismarck-brown in methylated spirit; leave in this vessel also for twelve hours at 30° C. In this way a double staining is produced, as the nucleus and nucleolus are stained a very transparent violet, while the cell-walls appear brown. The method, employed in the laboratory of the Royal Botanic Garden, of using glass vessels (3½ inches high with a 2 inches diameter at the base and a 3 inches diameter at the brim) as the receptacles for dyes, absolute alcohol, &c., is very handy, for a dozen slides can be stained simultaneously, and both hæmatoxylin and bismarck-brown be used again and again. Ehrlich's acid-hæmatoxylin I have also used, but find that it does not give the same transparency to nucleoli, &c. Here a word of warning may not be out of place to all who intend to investigate the nucleolus. Beware of overstaining! A section with deeply stained nuclei looks beautiful under a low magnifying power, but is of no use whatever for minute investigations. Other stains used for differentiating the nucleolus were heliocin and methylene blue, nigrosin and eosin, nigrosin and hæmatoxylin.* Sections stained as indicated should be very thoroughly dehydrated, then cleared in resinified turpentine (not in clove oil, as the latter causes considerable shrinkage) and mounted in canada-balsam dissolved in turpentine, as this balsam has a considerably lower refractive index than either chloroform-balsam or benzol-balsam.

If these instructions be followed in all their details I believe my results will be confirmed, in the main points at any rate, if not entirely so.

* Trans. Bot. Soc. Edin., vol. xix. (January 1891) p. 46.

The sections were examined with a one-twelfth Homogen. Immers. Zeiss, for the loan of which I have to thank Dr H. Stiles, and with Professor Rutherford's one-eighteenth Homogen. Immers. Zeiss. I take this opportunity to express my sincerest thanks to Professor Rutherford for the great kindness and courtesy shown me whilst working in his laboratory, and also to thank his assistant Dr Carlier for his constant willingness to help me in my difficult investigation, a help the more valuable to me for the great experience and capability of the latter as a microscopist. All my drawings were sketched with the help of a Zeiss' camera lucida, and not only the outlines of cells, but the minutest details were traced in this way.

After this long, but not unnecessary introduction, I shall give a description of the development of the embryo-sac based on my illustrations, Plates III*a* and IV.

When a flower of *Myosurus* is fully expanded the gynæceum consists of an elongated axis bearing at its base a number of mature achenes, at its apex a number in earlier stages of development. This condition enables one, as Strasburger points out, to get in one longitudinal section most of the essential stages illustrative of the ordinary development of an ovule, still I did not rely for the study of the earlier stages on sections made through expanded flowers alone, but preferred to select for examination of each of the earlier phases such flowers as showed most ovules in the required stage, for I soon found if two ovules be selected at the same stage of development, but one be taken from the apex of a matured flower while the other be taken from the base of a young flower, that in the latter each individual cell attains a larger size.

The life-history of the ovule up to the time of fertilisation may conveniently be divided into three stages:—

1. An early stage including the formation of the embryo-sac-cell.
2. An intermediate period ending with the formation of eight nuclei within the embryo-sac.
3. A final stage, during which the ovum matures and the primary endosperm-cell is formed by a conjugation of two sexual primordial cells.

A. Early Stage.

In a young ovule (fig. 1) we may readily distinguish a differentiation of cells into a protective layer or dermatogen (*derm.*), a generative layer or periblem (*peribl.*), and a conductive axis or plerome (*pler.*).

The dermatogen does not show anything peculiar except the slightly elongated shape of the cells at the apex.

The periblem-cells are evidently much elongated radially, abutting with one end on the plerome-axis and with the other end on the dermatogen. The central periblem-cell (*xx*) forming the direct elongation of the plerome is the physiological archesporium, *i.e.*, the cell which will perform its physiological function of ultimately giving rise to sporocytes. It is surrounded by a number of non-physiological archesporia, which, for reasons we shall understand better afterwards, do not perform their physiological function of developing into sporocytes.

The terminal plerome-cell shows a number of facets, each of which corresponds to the basal end of a periblem-cell.

In a slightly more advanced stage (fig. 2) the ovule has commenced to curve downwards and the true archesporium (*A.S.*), now evidently the largest cell in the ovule, is about three times longer than it is broad; if, however, the carpellary leaf interfere with the downward curvature of the ovule and if it press against the apex of the ovule, the archesporium cannot increase so much in length, but evidently makes up for this defect by attaining a great breadth. In this way we have to account for the difference in the form of archesporia (*A.S.*) seen in figs. 2 and 5, as compared with those shown in figs. 3 and 4. After the archesporium has attained a size as in figs. 2, 3, its lateral walls lose their straight outline and begin to bulge out (figs. 4 and 5), without producing, however, any visibly injurious effects on the periblem-cells surrounding it. The nucleus keeps step with the increase in size of the archesporium (fig. 4), almost touching the lateral or periclinal walls, while the nucleolus remains small.

During division the nucleus gives rise to a large monaster (fig. 5), one pole of which is placed very close to the dermatogen, while the other pole is placed at some distance from

the plerome-element; in other words the greater portion of the monaster occupies the apical half of the archesporium, *i.e.*, the half lying next the dermatogen, and the position of the chromatin-segments gives us an indication as to the level at which the cell-plate will be laid down later on. The monaster figured shows two sets of filaments or fibrils, a set of thick, deeply stained and centrally placed ones to which the chromatin-segments are attached, and a peripheral set of delicate feebly stained ones, to which no chromatin-segments are attached.

In a later stage of division (fig. 6), in which the new cell-wall is being laid down in the form of granules we note an inequality in the size of the two daughter-cells x and y, the cell y lying next the plerome-elements being the larger, the nucleus of the cell y is elongated radially, *i.e.*, the long axis of the nucleus is parallel to the long axis of the mother-cell, while the nucleus of the cell x is elongated tangentially, *i.e.*, the elongation is at right angles to the long axis of the mother-cell. The meaning of this difference in the shape of the two nuclei becomes evident on studying the future history of the two cells derived from the archesporium (figs. 7 and 8). In fig. 7 the nucleus of the cell x has become still more broadened out tangentially; in fig. 8 it is represented as a diaster; and in fig. 9 division has been completed. Similarly we find in fig. 7 the nucleus of the cell y of fig. 6 in the diaster stage, and its division completed in fig. 8. Thus the cell x (fig. 6) has divided anticlinally (fig. 9), while the cell y (fig. 6) has divided periclinally (fig. 8), and we must look upon the slightly oval shape of the two nuclei x and y (fig. 6) at this early stage of nuclear reconstruction as an indication of what will take place later on:—each nucleus is already elongated at right angles to the plane of division, and therefore its long axis corresponds to the direction of the nuclear barrel.

Four cells are thus derived from the physiological archesporium (figs. 2, 3, 4, *A.S.*), as the latter divides firstly by a periclinal wall (fig. 6) into a larger basal cell y, and a smaller apical cell x, and as the cell y redivides periclinally into two cells (y and *E.S.*, figs. 7, 8); the cell x redividing anticlinally into two cells (figs. 7, 9^a). Only once I found the apical cell x to divide undoubtedly periclinally (fig. 9^b),

and such a division may also have occurred in the ovule (fig. 12), in which the cell x shows a sharply defined and deeply stained portion beneath the dermatogen.

The division of the archesporium into four cells seems to be the rule in the ovules of a young bud; if, however, ovules be examined which develop at or after the time a bud has fully expanded into a flower, the archesporium is found to give rise to only three cells (figs. 10 *a–d*, 11–13 *a*), as no division of the cell x (figs. 6 and 7) takes place. The explanation of this difference does not seem to be difficult:—The basal ovules of a young flower will be better supplied with nourishment than the apical ovules of a mature flower, and hence the greater amount of nutritive material at the disposal of a basal ovule will give each individual cell in that ovule a greater chance of fulfilling its function. How different if food is scarce and the competition between cells severe! The cell placed most advantageously for having its wants supplied will thrive, while the remaining cells have to struggle against odds, and will succumb in the end. This bitter struggle is clearly shown in the ovule; for what is the cause of the development of the central periblem-cell into the archesporium (fig. 2, &c.), of the unequal division of the archesporium (fig. 6), of the larger cell thus derived preceding its sister-cell in division (figs. 7, 8), or the smaller cell (figs. 11, 13 *a*) not undergoing division at all?—The reason has to be looked for in the fact that the successful cell lies in each case in close contact with the plerome-elements, and that hence it is supplied directly with food-material, which travels to the ovule along the plerome-tract. For the same reason each one of the four cells derived from the physiological archesporium may attain an exceptional size, if the competition in the ovule has not been as great as usual, due to the development of a smaller number of periblem-cells than normal (fig. 9^a).

The next change we have to notice is a peculiar gelatinous swelling of the walls of the three or four cells derived from the archesporium (figs. 9^a, 9^b, 10 *a–d*). This change is in most cases restricted to the two periclinal walls between the cells x, y, and *E.S.* (fig. 10 *a*); next in frequency the condition is found in which again the two transverse walls are swollen, but in addition also portions of the anticlinal

walls of the cells x and y (fig. 10 *b*). Not at all unfrequently, especially in vigorous ovules, all the walls, with exception of those lying in direct contact with the plerome and the dermatogen (fig. 9[a], 10 *c*, 10 *d*), show the characteristic change. During the early stages of the gelatinisation the cell-walls stain deeply with Kleinenberg's hæmatoxylin, and on surface section (fig. 10 *c*, *y*) the whole cell-wall may appear as a dark violet plate.

This gelatinous swelling of the cell-walls occurring in the three or four cells derived from the archesporium is in every respect analogous to the swelling which takes place in the sporocyte-walls of other sporangia, *e.g.*, in the pollen-sacs of Angiosperms, in *Selaginella*, &c. As further, this change in the walls is, at least in *Myosurus*, not restricted to those cells not undergoing further development, but as it also occurs in the young embryo-sac-cell, all the cells derived from the archesporium and showing this gelatinisation must be regarded as sporocytes. Of the number of sporocytes formed in Angiosperms one only normally undergoes further development, and ultimately gives rise to the embryo-sac with its eight nuclei.

That the embryo-sac of Angiosperms must correspond to one sporocyte was a conclusion I had arrived at in my last paper *; but, notwithstanding this, I reason on the very next page that it must be the equivalent of two sporocytes. This mistake was brought about thus: Trying to disprove the view that the archesporium might be regarded as a sporocyte, I stated that it did not always give rise to four cells, but that it might give rise to a number of cells, varying from two to seven; as further, my mind had been greatly impressed by the constancy with which each sporocyte in the higher plants gives rise to four spores, and, as finally, I was aware of two groups of four nuclei always occurring in the embryo-sac, I was led to believe each of the two groups of four nuclei to be derived from one sporocyte, which naturally would make the embryo-sac the equivalent of two sporocytes. This latter conclusion being at variance with the conclusion I had arrived at at first, an explanation was sought, which resulted in the following:—"The division of the embryo-sac makes the

* Trans. Bot. Soc. Edin. (June 1891), pp. 136–148. The conclusion will be found on p. 140.

impression, as Ward points out distinctly, of being similar in nature to those preceding it. We know, further, that the walls of spore-mother-cells" (*i.e.*, sporocytes) "break down whenever spores are reaching their maturity—that they are, in other words, very transient; in the embryo-sac this process of dissolution of the wall seems to take place even before spore-formation, or rather no definite wall can be laid down, partly due to the vacuole," &c.

I was led to criticise my own paper on reading an article by Guignard,* on the formation of sexual nuclei in plants, who comes to the conclusion that the nucleus of a pollen-mother-cell (sporocyte) is comparable to the primary nucleus of the embryo-sac, as he finds that in *Lilium Martagon* both nuclei contain at the time of their formation twenty-four chromatin-segments, and that on their division each daughter-nucleus contains only twelve segments, *i.e.*, the number of chromatin-segments has been reduced by half in the four pollen-grains and in the eight nuclei within the embryo-sac,—a deficiency to be made up again at the time of fertilisation. A similar reduction in the number of chromatin-segments is stated to occur in *Fritillaria, Tulipa, Allium, Alstrœmeria* and *Listera*. The nuclei of the pollen-mother-cell (sporocyte) and of the embryo-sac being thus comparable, the author comes to the conclusion that the embryo-sac is comparable to the pollen-mother-cell, *i.e.*, it must be a sporocyte.

How this discovery affects our interpretation of the eight structures within the embryo-sac, I shall discuss after I have described the changes in the embryo-sac leading to the formation of the two groups of four nuclei.

Before proceeding with the investigation as to the fate of the young embryo-sac and its sister-cells, I shall state briefly the changes in the non-physiological archesporia, and describe shortly the early development of the single integument of the ovule.

The non-physiological archesporia, some of which, in direct contact with the true archesporium, equal the latter in size during the early stages of development (fig. 1), soon undergo oblique divisions (figs. 2, 3; × has been placed on the oblique division-walls) and periclinal divisions (fig. 7 on the

* Comptes Rendus, cxii., 1891, p. 1074. My attention was drawn to this paper by a review in the Trans. Roy. Micr. Soc., London.

right side of the cells derived from the true archesporium. That the sections through the ovules are not oblique, and that we are really dealing with oblique divisions, is proved by fig. 4, in which the cell *a* is showing a diaster with the equatorial plane placed obliquely to the long axis of the cell. The development of the integument from the dermatogen is shown in figs. 2, 4, 9[a], 12, 14, 15. The integument grows more vigorously on the superior convex surface of the ovule as compared with the lower concave surface. How the curvature of the ovule upon itself causes a compression of the cells of the dermatogen just where the ovule is connected to the mother-axis, and how this same curvature leads to disorganisation of the integument between the funicle and the nucellus or body of the ovule, may also be gathered from the above figures. This compression and disorganisation proves that the ancestral ovule must have been an erect structure, with an integument surrounding it on all sides; but, that from some cause or other—maybe by the rapid growth of the carpellary leaf, the latter ensheathing the ovule on all sides—the upward growth of the ovule was interfered with, and that it thus was forced to grow downwards in the direction of least interference.

B. The Intermediate Period.

We have already seen how of several original archesporia only one performs its physiological function of giving rise to a number of sporocytes, and we shall find that of these sporocytes, again, only one will fulfil its physiological function of giving rise to spores. This latter I shall call—analogously to the terminology applied to the archesporium—the physiological sporócyte, while those sporocytes not undergoing further development will be the non-physiological ones.

It has been pointed out, how, of the sporocytes derived from the archesporium, the one lying next the plerome (figs. 7–9[a], *E.S.*) is the one placed under the most favourable conditions with regard to the supply of food, and how, further, its cell-wall, abutting on the plerome, does not undergo gelatinisation,—a fact which can be explained on the supposition that the embryo-sac-cell has become parasitic in its habits, and that a swelling of its wall lying next the source of

food would interfere with the absorption of the latter, an explanation which must be admitted from an evolutionary standpoint.

Following out the history of the young physiological sporocyte or embryo-sac-cell, we find it at first of the same size as the non-physiological sporocytes (fig. 7), but soon greatly enlarged (fig. 10 *b*, 10 *c*, 10 *d*). This enlargement does not, *per se*, produce compression and degeneration of the other sporocytes, for one finds that the protoplasmic contents of the latter retain their normal appearance for a considerable time (figs. 8, 13 *a*). Later on, however, a marked change takes place, due to two causes, namely, starvation—as all available nourishment is taken up by the embryo-sac-cell—and pressure exerted by the surrounding nucellar cells. We see, therefore, in fig. 11 the sister-cell *y* of the embryo-sac-cell starved to such a degree that its lateral walls are no longer able to resist the pressure of the surrounding cells, with the result that they have been pushed in. Instead of the sister-cell being the first to degenerate we frequently find the sporocyte *x* of figs. 9^a, 11, to collapse first as shown in fig. 14. Sooner or later all the other sporocytes are starved to death by the embryo-sac-cell, their nuclei and protoplasm travel towards the apical part of each cell and there form a readily stained mass (figs. 12, 13 *a*, *x*). Ultimately only traces of the non-physiological sporocytes remain, forming a covering for the apex of the physiological sporocyte, which Strasburger very appropriately calls the cap of the embryo-sac-cell (figs. 15, *x*, *y*, 25–27, 29, 30).

The physiological sporocyte or embryo-sac-cell at the time of its formation is filled with finely granular protoplasm, and possesses a comparatively large nucleus, poor in chromatin, and a nucleolus which occasionally seems to give rise to a number of accessory nucleoli (fig. 8, *E.S.*). As the cell gets older the chromatin-matter of the nucleus increases in amount, the nucleolus swells markedly (figs. 9^a, 11, 13 *a*, 13 *b*, 14),* and a vacuole makes its appearance close to the apical part of the nucleus (fig. 12), increasing gradually in size (fig. 15). The apical part of the embryo-sac-cell seems to be the usual site in which the vacuole appears, if

* The minute structure of the nucleus and nucleolus will be described later, p. 383.

ovules taken from a fully expanded flower be examined, and only very rarely does it arise in the basal half of the cell, fig. 16.* In ovules taken from immature flowers I have frequently found in the earlier stages an apical and a basal vacuole (fig. 14) or three vacuoles (fig. 9[a]), and in the later stages a great number of vacuoles of all sizes towards the apex and the base of the embryo-sac-cell (fig. 13 *a*, 13 *b*). Whether this bears out Went's observations,† that vacuoles never appear *de novo*, but that each vacuole is derived from a pre-existing one, just as each nucleus and each cell is derived from a previous nucleus or cell, I am unable to say, but I have been unable to detect a vacuole in very young sporocytes.

What are these vacuoles? Have they to be considered as indications of degenerative processes going on in the protoplasm of the cell? Is the protoplasm becoming infirm and old and no longer able to fulfil its task and to keep step with the growth of the cell? These views can hardly be accepted, if we consider for one moment what an amount of energy there is in the young cell and how complicated the changes are it must undergo before it can give rise to the mature embryo-sac. May we not consider vacuoles as expansions of the channels by which fluid is normally conducted in the cell, rather than holes arising in the protoplasm because of senile changes? Expansions developed to play an important part in the physiology of the cell and to perform definite functions? One of these functions seems to be that of dilating the cell-wall to allow the protoplasm and the nucleus to react on the tense walls, and to model them according to requirements. But how can a vacuole perform this function? The sap within the vacuoles is rich in salts, hence a tendency to diffusion of fluids of less high specific gravity into the vacuole must exist, and this tendency regulated by the protoplasm in direct contact with the vacuole according to its needs, will cause a pressure to be exerted on the cell-walls from within.

The effect of the increase in size of the embryo-sac-cell

* All the figures from fig. 16–45 are arranged in such a way that the apical or micropylar part of the embryo-sac is pointing upwards, while the basal or antipodal part is pointing downwards.

† Went in Pringsheim's Jahrbücher, vol. xxi., 1890.

on the nucellar cells surrounding it is shown in an early and in two advanced stages in figs. 15, 27^a, 30.

The next step in the life-history of the cell is its division, and I regret to say that, amongst the many thousands of sections I have made through flowers of all ages, I have not found a single ovule throwing light upon the way in which this division takes place. From Strasburger's brilliant researches we know that indirect division occurs in other plants, but how it takes place in *Myosurus*, and what becomes of the vacuoles during the time of division I am unable to state. Strasburger states that no division of the protoplasm occurs after the division of the nucleus of the sporocyte (Strasburger's primary nucleus of the embryo-sac-cell), and therefore concludes that the two newly formed nuclei can not be regarded as the nuclei of two sporocytes (Warming-Vesque view), but that they must belong to one individual structure, namely, the female prothallus of a macrospore; in other words, that the cell I have called the physiological sporocyte is a spore giving rise to a female prothallus, and is not the equivalent of two sporocytes. Already it has been pointed out that the embryo-sac-cell must be a sporocyte, because of the gelatinisation occurring in its walls, and because of the nucleus of the embryo-sac-cell being comparable to the nucleus of a male sporocyte according to Guignard's observations, and a third reason will become apparent as we trace the further history of the two nuclei.

The earliest stage I have found after the division of the nucleus of the physiological sporocyte (Strasburger's primary nucleus of the embryo-sac) is represented in fig. 16, showing a sac with an apical and a basal nucleus surrounded by protoplasm and a large vacuole in the centre of the protoplasm. There is thus no division of the protoplasm corresponding to that of the two nuclei. In the next figure (17^a) the vacuole is bounded at both ends by a mass of finely granular plasm, on the left by the sac-wall, and on the right by a delicate layer of plasm connecting the apical nucleus with the basal one. Fig. 17^b shows the protoplasm of the sac aggregated at the two ends and the vacuole in direct contact with the cell-wall.

What may happen next is the formation of a membrane (*m*, fig. 17^c), which separates the apical part of the proto-

plasm from the vacuole and thus form the basal part of the sac. This membrane is not always laid down, but may, on careful examination, be found in at least 50 p.c. of ovules, and it is seen in figs. 18, 19, 21, 22, 23. Fig. 18 shows the membrane *m* placed obliquely [the anterior margin *a* has been represented as a darker line than the posterior one *p*], evidently separating the apical portion of the embryo-sac from the basal one, and bounded on either side by a vacuole. The apical vacuole is brought about thus:—As the ovule elongates, the embryo-sac keeps step with the elongation, and the apical protoplasm gradually recedes from the membrane, which latter, by retaining its position, indicates the basal limit of the apical protoplasm soon after the division of the sporocyte-nucleus. In fig. 19 the membrane exhibits a distinct double outline, and fig. 21, although a later stage in the development of the embryo-sac, shows a portion of the apical protoplasm still adhering to this membrane. Once I found two distinct membranes crossing the embryo-sac (fig. 22), and I believe the lower membrane m^1 to have been formed first, the membrane m^2 afterwards.

The question arises:—What is the significance of this membrane? If the embryo-sac is nourished by food coming from the plerome-elements on which the basal half of the sac abuts, one would not expect that the apical half would shut itself off from the supply of nourishment by a double barrier, namely, the vacuole and this membrane, provided it was not able to procure its food-supply from some other source. Such another source seems to exist, for the constantly increasing size of the embryo-sac results in the compression and the degeneration of the periblem-cells surrounding it, and I believe that by the death of these cells albuminoid materials are set free which serve as food-material for the apical cell. This suggestion would also explain why in many ovules no membranous partition is formed:—If food-material is not procured in sufficient quantity from the degenerating periblem-cells, then the apical nucleus and its protoplasm must rely for their supply partly on the nutriment brought to the basal end by the plerome-elements, and hence a protoplasmic communication between the two halves of the embryo-sac becomes necessary and no membrane will be formed.

As this membranous partition divides the embryo-sac into an apical portion lying next the micropyle of the ovule, and into a basal portion, in which latter the so-called antipodal cells are developed, the apical and basal portions will henceforward be called the micropylar and the antipodal ones.

To return to Strasburger's contention that the embryo-sac is a macrospore:—Is it likely that an embryological-cell, such as a macrospore, whose function it is to give rise to one prothallus, will divide into two portions or cells quite independent of one another? By a supposed analogy to the microspore or pollen-grain, the view was advanced, that the first division of the nucleus of the embryo-sac-cell gave rise to a vegetative and a reproductive part, the former corresponding to the basal half of the embryo-sac, while the latter corresponded to the apical half. But is the reproductive cell of a pollen-grain independent of the vegetative cell? Certainly not, for to the vegetative cell falls the share of producing the pollen-tube, while the reproductive cell is concerned in fertilisation.

We have seen that the micropylar half of the embryo-sac may lead an existence independent of the antipodal half, a fact which compels one to regard the two halves of the sac as homologues.

One more question must be answered: Why does the embryo-sac-cell, after the division of its nucleus, not lay down a definite cell-wall, and separate into an apical and a basal half? One reason may be that the vacuole or vacuoles, which arise in the micropylar and antipodal ends of the embryo-sac-cell before its division, are shifted in some special way either during or after karyokinesis into a position midway between the two newly formed nuclei, *i.e.*, into the very place where normally a new cell-wall should be laid down. Another reason may be this:—If the embryo-sac-cell is a sporocyte, then its first division will correspond to the first of the binary divisions of other sporocytes, *e.g.*, pollen-grains, and we know that in pollen-grains the second of the binary divisions may follow upon the first, without a cell-wall having been laid down after the first division. A third reason has been fully explained at the bottom of the previous page (363).

In the antipodal end of the sac a small vacuole (fig. 19)

is sometimes developed, which, on the division of the antipodal nucleus, takes up a position between the two newly formed nuclei (fig. 23).

After a time division of the two nuclei in the embryo-sac (figs. 16, 17[a]–[c], 19) takes place, and thus four nuclei are formed (figs. 20–23). In fig. 20 we see that the antipodal nucleus is both the most advanced in division and that it gives rise to a much larger diaster than the micropylar nucleus. In several sections I have noticed in the embryo-sac, both at this stage (fig. 23) as also after the formation of eight nuclei, spherical colloid-like masses not stained by hæmatoxylin (*H. B.*), the origin of which I was unable to make out. In fig. 24 the four nuclei within the embryo-sac are undergoing division to give rise to eight nuclei. Similarly as in fig. 20 we notice how the two antipodal nuclei are more advanced in division than the two micropylar ones, and that again of the two antipodal ones, the one next the plerome has advanced the furthest. The centre of the sac is occupied by a large vacuole, and there is no protoplasmic connection between the apical or micropylar, and the basal or antipodal halves of the embryo-sac.

One diaster (*syn*) is placed at the very apex with its long diameter at right angles to the long axis of the sac; it is again seen in a later stage of division in fig. 25[a], and after completion of the division *syn*, in figs. 25[b], 26, 27, 29[b]. The two cells arising from this diaster have been called by Strasburger, the synergidæ, as they were believed to play an important part in conveying the male fertilising-element of the pollen-grain to the egg-cell. The second micropylar diaster (*ov.* fig. 24) is placed obliquely, and its function is to give rise to two nuclei, one of which surrounds itself with a mass of protoplasm, and forms a thin membrane on the outside of this protoplasm, and thus shuts itself off from its sister-nucleus. This third cell arising in the micropylar half of the sac and provided with a definite membrane, develops into the egg-cell or ovum (*ov.* figs. 25[a], 25[b], 26[a], 28, 30, 31). The sister-nucleus of the egg-nucleus lies imbedded in a mass of protoplasm (*m. p. c.*, fig. 25[a]), and does not surround itself with a definite membrane, and has therefore to be regarded as the nucleus of a free or primordial cell. The latter is bounded above by the two synergidæ and the

ovum, below by the vacuole, and on its sides by the walls of the embryo-sac. This fourth cell I propose to call, because of its position and its nature, the micropylar primordial cell (*m. p. c.*, figs. 25[a], 25[b], 26, 27, 28).

In the basal half of the embryo-sac (fig. 24), we again find two diasters, one occupying the very base of the sac (*ant.*) and a second one (*ant.* + *p.*) placed obliquely to the former. The diaster (*ant.*) gives rise to two antipodes, which occupy the base of the sac (fig. 25) the line *i–i* indicating their upper border, while the remaining diaster (*ant.* + *p.*, fig. 24) gives rise to two nuclei, one of which surrounds itself with protoplasm and a cell-wall, and becomes the third antipode, while its sister-nucleus surrounded by naked protoplasm is equivalent to a primordial cell, bounded above by the vacuole, below by the antipodes, and laterally by the embryo-sac-walls (*a. p. c.*, figs. 25[a], 25[b], 26, 27, 28). This primordial cell occurring in the basal half of the embryo-sac I shall call the antipodal one, to distinguish it from the cell arising in the apex of the sac, namely the micropylar primordial cell.

To recapitulate shortly we find the embryo-sac to contain in its micropylar end two synergidæ, one ovum and a primordial cell; in its basal end a primordial cell and three antipodes, *i.e.*, each end of the sac contains four cells, making in all eight cells.

What changes take place in the ovule during the maturation of the embryo-sac will have to be studied next, as these changes throw much light on facts which constantly occur in connection with the two groups of four cells enclosed by the sac.

During the earlier stages of development the embryo-sac increases in size mainly at its micropylar end, and hence the periblem-cells of the ovule lying between that end and the dermatogen are the first to suffer; they degenerate and form, along with the remains of the non-physiological sporocytes, the cap round the apical one-third of the sac. When the embryo-sac is no longer able to increase in the micropylar direction, it begins to bulge out laterally, enfeebles the nucellar periblem-cells surrounding it, and ultimately kills them. This latter change takes place in a very definite way, as the degeneration spreads from the apex of the ovule down to its base (fig. 27). That this should be so is explainable, for

the cells nearer the base of the ovule are older, more resisting and better fed than those at the apex. At the time of maturation we find the ovule (fig. 30) to consist of the dermatogen, the remains of the nucellar periblem-cells and the enormously increased parasitic sporocyte or embryo-sac.

Let us return to the two groups of eight cells within the sporocyte-sac. The synergidæ at the time of their formation (fig. 25[a], *syn*) are attached by a broad base to the most apical part of the embryo-sac, are almost isodiametric and enclosed in a firmer wall than the ovum or egg-cell. Very soon, however, the synergidal cells change their shape, due to growth taking place parallel to the long axis of the ovule (fig. 25[b]), and still later one vacuole is formed in the basal end of each cell (fig. 26, *syn*). To what extent the synergidæ may elongate can be gathered from fig. 29[a]; (the elongation and vacuolation are not seen in figs. 27, 30, 31 as the lower ends of the synergidæ are lying in the next serial sections).

The egg-cell is placed on a slightly deeper plane than the synergidæ (figs. 25[a], 28, *ov*) with its nucleus and the greater part of its protoplasm towards the antipodal end, the micropylar end being occupied by a vacuole. Thus we have, as has been pointed out by Strasburger long ago, in the ovum or egg-cell a condition the very reverse of that occurring in the synergidæ; a difference well seen in fig. 28, showing one synergida (*syn*) with a vacuole in its antipodal half, and an ovum (*ov*) with a vacuole in its micropylar half. How we may account for this phenomenon, I shall attempt to explain, after I have alluded to the fate of the two primordial cells.

The micropylar (*m.p. c*) and the antipodal (*a.p. c*) cells are at first not connected by protoplasmic strands (fig. 25[a], 25[b]), but later protoplasmic connections are established (figs. 26, 27[a], 28, 29[a], 30, 31), and the nucleus of the antipodal cell travels towards the nucleus of the micropylar cell, both nuclei unite and give rise to what Strasburger has called the secondary nucleus of the embryo-sac. Thus a protoplasmic connection is established between the micropylar and the antipodal halves of the embryo-sac. To return to the synergidæ and the ovum:—It has been pointed out how the enlargement of the embryo-sac leads to a degeneration of the nucellar periblem-cells, a degeneration which commences at the apex of the ovule and then gradually spreads towards its

base. We find now at the time of the formation of the synergidæ the retrogressive changes of the periblem-cells restricted to the apical portion of the ovule, and it is quite conceivable that by the breaking down of cells, food-materials will be set free which are directly available to the cells lying in the apical portion of the embryo-sac. Glancing at figs. 24 and 25 *a* we see that the two synergidæ (*syn*) occupy the most apical position in the sac, in other words, that they are the two cells next the supply of food, and it is natural that as the embryo-sac elongates, the nuclei and the protoplasm of the two synergidæ should continue to lie in as close a connection as possible with the apical part of the sac, *i.e.*, the supply of food. To accomplish this the cells must keep step with the elongation of the sac, and hence a vacuole is formed in the basal end of each cell; its function being to increase the tension within the cell and to allow the nucleus and the bulk of the protoplasm to recede from the basal unprofitable end to the micropylar end where supply is plentiful.

The egg-cell is usually placed to one side of the two synergidæ, and at a somewhat lower plane, *i.e.*, further removed from the region in which nucellar cells are degenerating. If then my contention of food-material passing into the micropylar end of the embryo-sac be correct, the egg-cell will not be supplied with nourishment to the same degree as the two synergidæ; and the sister-cell of the ovum, the primordial cell, which, as we have seen above, lies below the synergidæ and the ovum, will be as regards nutriment, the most unfavourably placed cell in the micropylar half of the embryo-sac. The latter cell placed under these disadvantages begins to look out for a new source of food, its protoplasm streams over the inner aspect of the embryo-sac and ultimately comes in contact with the protoplasm of the antipodal micropylar cell (figs. 25–31). The latter, however, is in the same distress as its neighbour, as I judge from the facts, that its protoplasm also is wandering over the inner aspect of the embryo-sac evidently in search of food, and that as in fig. 27 a branch (*l*) has even been sent out, between the antipodes and the sac-wall, to reach the plerome-elements which are the conductors of food-material to the ovule.

As the two primordial cells, whom hunger has driven to make acquaintance, cannot get any or only little nourishment from either the antipodal or the micropylar ends of the sac, they would have to degenerate if it were not for the presence of the large vacuole in the centre of the sac. This vacuole exerts pressure on the surrounding nucellar cells, enfeebles them and causes their degeneration ; a degeneration which supplies the primordial cells with nutriment. It has already been pointed out how this degeneration proceeds from above downwards, therefore most nourishment will be flowing into the micropylar end of the sac. This fact may explain why the nucleus of the antipodal primordial cell travels upwards into the micropylar half of the sac.

This history of the primordial cells gives us a clue as to the position of the vacuole in the egg-cell :—As the latter does not occupy the very apex of the embryo-sac, a position held by the synergidæ, and as further the growth of the embryo-sac during its early development is chiefly a growth in length, taking place at the very apex, the synergidæ will consume all available nutriment coming from the degenerating cells and leave the egg to its own resources. We have further seen how the two primordial cells were the most starved, and how through degeneration of the periblem-cells they were supplied with nutriment; as now the micropylar primordial cell lies in close contact with the ovum (figs. 26, 28, &c.), the latter will receive its food-supply from the degenerating periblem-cells through the medium of the protoplasm of the micropylar primordial cell. Fig. 28 illustrates how the protoplasm of the primordial cell (*m. p. c.*) forms a thick layer just beneath the ovum (*ov*), its sister-cell. As in the synergidæ, so here the nucleus and the bulk of the protoplasm tend to occupy that side of the cell through which nutriment is flowing in.

The three antipodes may be arranged in various ways according to the breadth of the basal end of the embryo-sac. To find all three placed side by side, with their long axes parallel to the long axis of the sac is common (figs. 25^a, 25^b, 26, 27), yet one cell is usually at a higher level than the two others, and this higher cell is the sister-cell of the antipodal primordial cell ; it may even (fig. 29^a) be placed above one of the other two antipodes.

Very rarely do we meet with a condition as shown in fig. 28, due to the diaster (*ant.*, fig. 24) being placed in the long axis of the sac instead of being placed, as usual, at right angles to it; in this ovule the third antipode (sister-cell to the antipodal primordial cell) was placed alongside the two shown.

At first the antipodes bulge into the cavity of the embryo-sac (fig. 25^a) and may continue to do so up to a comparatively late stage (figs. 27, 28, 29^a, 30), but as a rule they become concave on that surface next the interior of the sac, from two causes, namely, pressure of the central cell (the result of the fusion of the two primordial cells), and by being pulled outwards and stretched by the enlarging embryo-sac (figs. 25^b, 26, 31).

We shall have to consider next the difficult problem :—What is the nature of the eight cells within the embryo-sac.

Strasburger's researches have undoubtedly thrown the most light on the phenomena taking place within the embryo-sac, for he demonstrated how the "primary nucleus" of the embryo-sac divides into two nuclei, how these again divide and redivide, thus giving rise to eight nuclei, how, further, two of these develop into the two synergidæ, while one forms the ovum, three others form the antipodes, and the remaining two nuclei fuse and give rise to the "secondary nucleus" of the embryo-sac, a "nucleus" concerned in the formation of endosperm.

That these changes take place in the embryo-sac has been confirmed again and again, and their very confirmation has led botanists to accept the interpretation given to the embryo-sac by Strasburger after Hofmeister. Strasburger believes the embryo-sac to correspond to a macrospore, and considers the cells within the sac as the cells of a female prothallus. Yet facts have been discovered since Strasburger's researches were published, which show that the embryo-sac-cell can not be a macrospore, whatever else it may represent.

It has been pointed out in my previous papers, and also above, that the walls of the embryo-sac in *Myosurus* show a gelatinisation identical with that occurring in the sporocytes of all other sporangia, and that Guignard has established the

important fact, that the nucleus of the embryo-sac is comparable to the nucleus of a male sporocyte, namely, the pollen-mother-cell.

If then the embryo-sac-cell is not a macrospore but a sporocyte, then it must give rise to spores, and the question arises, to how many spores?

As during the further development of the embryo-sac-cell we find at successive stages, one, two, four, or eight nuclei within the sac, we might imagine that any one of the four stages could correspond to the period of spore-formation, *i.e.*, that the sporocyte or embryo-sac-cell might give rise to one, to two, to four, to eight spores respectively. Let us consider these four possibilities:—

If the sporocyte gave rise to only one spore, it would have to be converted directly from the sporocyte-condition into the spore-condition, and the eight nuclei within the mature embryo-sac would have to be regarded as eight nuclei of one prothallus developed from one spore.

Against this interpretation the following objections may be raised:—

1. A direct conversion of one sporocyte into one spore would have no analogue in the remaining vegetable kingdom.
2. The evident individuality of each half of the embryo-sac-cell after the division of the first nucleus, as manifested by the micropylar end receiving its nourishment from the degenerating periblem-cells, while the basal end is fed by the plerome-elements and by the formation of a plate on the basal surface of the micropylar cell (see p. 363), point against our accepting the two halves of the embryo-sac as belonging to the same individual structure.
3. The great constancy with which four cells arise in either end of the sac, also points to the two halves of the embryo-sac being the homologues of one another, and not vegetative and reproductive portions of one prothallus.
4. If, further, the apical half of the sac was a reproductive portion, while the basal half was a vegetative part, how could we explain the conjugation of the two primordial cells?

5. The cell-wall-formation round six of the nuclei is not in accordance with the normal way in which prothallus-cells grow, but is, as we shall see later, quite in accordance with the division of nuclei and the subsequent cell-formation as they occur in other sporocytes.
6. We have no indication of changes in the sporocyte, which we could explain as being due to the supression or non-development of the remaining three spores, supposing the division of a sporocyte into four spores as the normal.

May then the embryo-sac be the equivalent of two spores? If so, the first division of the nucleus of the sporocyte (Strasburger's primary nucleus of the embryo-sac) would have to be considered as the stage of spore-formation, and the two groups of four cells within the embryo-sac would correspond to two prothalli, namely, an apical one consisting of the two synergidæ, the ovum and the micropylar primordial cell, and a basal one consisting of the three antipodes and the antipodal primordial cell.

I shall discuss this two-spore hypothesis after having explained what a four- and an eight-spore hypothesis would lead us to.

If the sporocyte gave rise to four spores analogously to the way in which the male sporocyte or pollen-mother-cell gives rise to four pollen-grains, then the first division of the nucleus of the female sporocyte or embryo-sac-cell (figs. 16–19) would correspond to the first of the binary divisions of the male sporocyte, and the period at which four nuclei are found in the sac (figs. 20–23) would correspond to the time when the four pollen-grains are formed in the pollen-mother-cell.

We know that each of the four nuclei within the embryo-sac redivides, figs. 24 and 25, and that thus they give rise to differently named structures, namely:—

1. One nucleus gives rise to the two synergidæ.
2. „ „ to the egg-cell and micropylar primordial cell.
3. „ „ to the two antipodes next the plerome-element.

4. One nucleus gives rise to the antipodal primordial cell, and the third antipode which is placed on a slightly higher level than the two other antipodes.

Do these four groups, of two cells each, correspond to four two-celled prothalli? Are we dealing with eight spores? Or what interpretation has to be given to the eight cells?

Much light has been thrown on this difficult question by Dodel * in an able paper, which the author was so kind as to send me. While investigating the phenomena of fertilisation in *Iris sibirica* the author incidentally discovered the important fact that besides the egg-cell, one or both synergidæ may occasionally be fertilised, and even give rise to a few-celled embryo or embryos (*l.c.*, figs. 14, 16, 17). This discovery is summed up in the words: "There can no longer be any doubt that the synergidæ of *Iris sibirica* not unfrequently possess the characters of an egg-cell, as they have the power of receiving a sperm-nucleus, and of undergoing a true fertilisation in consequence of which even a several-celled embryo may develop."

Quite independently of Dodel's researches Overton † has discovered the same phenomenon in *Lilium Martagon*, and figured it. If then both synergidæ and the ovum may be fertilised by sperm-nuclei they must all three be sexual cells; but also the fourth apical cell (the micropylar primordial cell) must be a sexual cell as it conjugates with a cell from the basal or antipodal end of the embryo-sac. We find thus the micropylar half of the embryo-sac to contain four sexual cells, while the antipodal half contains normally only one. If we interpret the embryo-sac as the equivalent of two prothalli, we would have to consider the micropylar prothallus as consisting of four sexual and no vegetative cells, while the antipodal prothallus would be a prothallus giving rise to three vegetative cells and one sexual cell, which latter fuses with one sexual cell from the micropylar region.

The objection I have to the two-spore-hypothesis is shortly this:—Sporocytes normally divide into four spores

* Dodel, Befruchtungs-Erscheinungen b. *Iris sibirica*, Zürich, 1891.
† E. Overton, Entwickelung und Vereinigung d. Geschlechts-producte b. *Lilium Martagon*, Zürich, 1891, fig. 16.

as, *e.g.*, in the sporangia of vascular Cryptogams (whether heterospory occur or not) and in the microsporangia or anther-sacs of Gymnosperms and Angiosperms. As, further, no doubt exists about the sporocyte nature of the embryo-sac-cell we are compelled to explain the embryo-sac-cell on the four-spore-hypothesis.

Attention has already been drawn to the facts (p. 372) that of the four nuclei (figs. 20 and 23) of the embryo-sac, each gives rise to two nuclei, each of which in their turn develops into two cells (figs. 24, 25); that two groups of two cells arise thus in the micropylar end of the sac (*i.e.*, the two synergidæ + the ovum and the primordial cell), and that finally each one of these four cells may play the part of a sexual cell. In other words, the two spores lying in the micropylar half of the embryo-sac give rise to four sexual cells, *i.e.*, each spore gives rise to two sexual cells.

A comparison with the male spores or pollen-grains renders this explanation highly probable, for each pollen-grain divides normally into a vegetative and a reproductive cell, and the latter redivides, thus giving us two sexual cells for each pollen-grain or spore. Four pollen-grains being formed in each male sporocyte, and two reproductive cells in each pollen-grain will make a total of eight reproductive cells developed from one pollen-mother-cell, or male sporocyte.

Similarly the female sporocyte or embryo-sac-cell gives rise to four macrospores, and these in their turn to eight female sexual cells. The non-formation of cell-walls round the four macrospores, as well as the absence of all vegetative cells, may then be explained as due to the parasitic habit of the spores. It is quite conceivable that the microspores, which have to lead an independent existence for a longer or a shorter time, should not have been reduced to the same extent as the parasitic macrospores, and that for this reason vegetative cells still occur in the former.

Of the eight female sexual cells, one, the ovum or egg-cell, is fertilised by a male sexual cell, namely, one of the two sperm-cells developed from one pollen-grain; two sexual cells arising from different spores (the micropylar and antipodal primordial cells) conjugate and give rise to one large centrally placed cell, the primary endosperm-cell, the nucleus of which corresponds to Strasburger's "secondary

nucleus"; while the remaining five sexual cells (the two synergidæ and three antipodes) normally undergo no further development. That the synergidæ may be fertilised and thus play the part of true sexual cells has been proved, as stated above, by the researches of Dodel and Overton. It remains therefore to be proved that the antipodes are sexual cells, that they, in other words, have the power of conjugating. Whether they do conjugate I am unable to state definitely, but as I have found in *Scilla nutans* appearances as shown in figs. 49 *a*, 49 *b*, it is likely that they may do so. Both ovules, from which these drawings were made, are fully developed, the synergidæ degenerating and the ova unfertilised. In the antipodal halves of either ovule the cells figured are seen; in fig. 49 *a* the uppermost cell, which has formed a paranucleolus (*p n*), is the sister-cell of the ovum, but which of the four cells in fig. 49 *b* corresponds to the micropylar primordial cell it is impossible to say definitely, but it seems to be the cell marked (*m. p. c.* ?). The two groups of two cells flattened against one another at their point of contact in the second figure, certainly look very much as if they were on the point of conjugation.

Can we give a reason why the synergidæ and the antipodes normally do not behave as sexual cells?

We have already seen how the synergidæ, during their early development, are better supplied with food, derived from the degenerating periblem-cells, than either the egg-cell or the micropylar primordial cell;—how each synergida surrounds itself with a thick membrane, and thus shuts itself off from its fellow and from the rest of the embryo-sac;—how their nuclei lie at the micropylar end of each cell, *i.e.*, next the supply of food, while vacuoles are developed at the basal ends. Thus, every means has been taken by each synergida to procure for itself as much nourishment as possible, with the result that both thrive and assume bigger proportions than the egg-cell, and that both would fulfil their function, *i.e.*, be fertilised by sperm-nuclei from a pollen-grain, if it was not for the supply of nourishment becoming exhausted in the apical region of the ovule before the latter is fully developed. This new factor changes the whole aspect of matters, for the very causes which ensured the success and the development of the synergidæ during their early develop-

ment will now prevent nourishment getting to the nuclei of the synergidæ, with the result that the nuclei gradually degenerate and the synergidæ die.

If it is the want of nourishment that causes synergidæ to degenerate, why then do the antipodes, being freely supplied with nourishment, not undergo conjugation as the two primordial cells do? Because the very fact of each antipode being supplied abundantly with nourishment, will awaken in it the tendency to develop individually, a tendency associated with the loss of all desire to unite for individual benefit with another cell of its own kind. This individualisation of the antipodes seems to become so marked that the originally sexual cells may assume vegetative functions, and, parthenogenetically, give rise to the primordial endosperm in plants like *Zea Mais*, *Coix lacryma*, *Panicum Crus-galli*, *Salvia pratensis*, and some scrophularineous plants, for Westermeyer, who is the authority on antipodes, does not seem to have made out any conjugation of the antipodes, analogous to the appearances shown in fig. 49 *a*, 49 *b*.

In my previous paper it was shown that the fusion of the two nuclei was in reality only the last step in the conjugation of two cells, and I proposed to call the newly formed cell, the endosperm-cell, as it gives rise to the endosperm, and to call its nucleus the endosperm-nucleus. I imagined I had been the first to recognise this fact, but since then I have learned from Hartog's paper (*vide* later) that Le Monnier of Nancy was really the first person to express this view clearly.* Dodel (*l.c.*) has proposed to call the secondary nucleus the "primary" endosperm-nucleus, and I have adopted this full name for obvious reasons.

As formerly I held the view that the embryo-sac was the equivalent of two sporocytes I naturally came to the conclusion that the two conjugating cells were the equivalents of two spores, but as I have changed my views since then, and now regard the embryo-sac as one sporocyte, and the eight cells within it as corresponding to the eight male reproductive cells which develop from one pollen-mother-cell, I must modify my previous explanation, and therefore state that I believe the endosperm-cell to arise by the union of two sexual cells which are derived from different spores. This

* In Morot's Journ. d. Bot., vol. i. p. 140 (June 1887).

endosperm-cell must, however, in any case be regarded as a true embryo, as it results from the union of two sexual cells. It is destined to act as a storehouse for the stronger embryo which develops from the cross fertilised egg-cell,—meaning by cross-fertilisation, the fertilisation by an extraneous sexual cell, *i.e.*, a sexual cell derived from the anther-sac or microsporangium of the same or of a different flower.

My new interpretation of the embryo-sac does away also with the suggestion that we might regard the micropylar end of the embryo-sac as a female sporocyte, giving rise to four macrospores, while the antipodal end was to be regarded as a male sporocyte giving rise to four microspores, a conclusion I stated thus:—"The egg-cell in the micropylar region receives the contents of the pollen-tube and develops into the embryo; it is therefore a true female cell, and its sister-cell I would expect to be also a female cell, and I find that the nucleus of the antipodal cell travels towards the nucleus of the primordial micropylar cell, and that in *Myosurus* the two nuclei meet in the micropylar half of the sac."

Reasons different from those I imagined lead to the conjugation of the two primordial cells, the main of which I believe to be *hunger* as has been pointed out already. Let us study next, how this hunger is satisfied.

C. Final Stage.

Before commencing with our study of conjugation, it is necessary to give a number of definitions of terms used:—

The cell-plasm is that plasm of a cell outside the nuclear membrane.

The nucleus is the plasm between the nuclear and nucleolar membranes.

The nucleolus is the plasm within the nucleolar membrane.

I have thus made the nuclear and the nucleolar membranes the land-marks for the division of the protoplasm of a cell into three zones, and have avoided classing the membranes under any one of these three layers, although I am inclined to consider the nuclear membrane as part of the cell-plasm (after Strasburger), just as the nucleolar membrane will probably have to be regarded as the innermost portion of the nucleus, as will become apparent later on.

We have already seen how the micropylar primordial cell

(*m. p. c.*, fig. 25[a]) occupies a position beneath the two synergidæ (*Syn*) and the ovum (*ov*), and how the antipodal primordial cell (*a. p. c.*, fig. 25[a]) lies in close contact with and above the three antipodal cells (*ant*). The cell-plasm of the micropylar cell does not occupy a large portion of the embryo-sac-wall, while the antipodal cell on the right is attached by a broad base to the sac-wall. As the ovule gets older, the cell-plasmata of both primordial cells commence to wander over the inner aspect of the sac (fig. 25[b]), and thus shut off the vacuole from the sac-wall in the upper and lower portions of the embryo-sac, but as yet the vacuole touches the wall at the places (*p. p.*, fig. 25[b]). In a slightly older ovule (fig. 26[b]), the cell-plasm of the micropylar cell has commenced to stream over the inner aspect of the sac, and we see, in a mesial section through the same ovule (fig. 26[a]), how the antipodal cell has also sent out long pointed processes, how further, two of these processes, one from either end of the embryo-sac, have formed a distinct protoplasmic connection between the two primordial cells (see left side of same figure). Thus the initial step in the conjugation of the two primordial cells has been brought about; the movement of the protoplasm reminding one vividly of the formation of pseudopodia in an amœba, or of the plasmodia in a myxomycete.

In fig. 27[b], the inner aspect of the sac is lined by protoplasm arranged in a reticulate manner with nodular swellings, while in fig. 27[a], representing the next section through the same ovule, the position of the two nuclei of the primordial cells is illustrated; we see, further, in the same figure that the antipodal cell-plasm has made its way between the true antipodes and the nucellar cells (*l*).

The conjugation of the cell-plasmata then becomes very evident along one side of the sac, fig. 28, and the antipodal nucleus (*a. n.*) begins to travel towards the apical end of the sac, while the micropylar nucleus (*m. n.*), lying close to the membrane of the egg-cell (or below and between the egg-cell and the synergidæ, fig. 27[a]), remains stationary. The antipodal nucleus may, in some instances, continue to move along the wall of the sac, but one more commonly finds a thick strand of protoplasm detaching itself from the wall and forming a column which joins the antipodes with the syner-

gidæ; along this strand the antipodal nucleus approaches the micropylar (fig. 29ᵃ, 29ᶜ). The nuclei are represented in three stages of approximation in figs. 29^a, 29^b, 29^c, both are evidently lying in the micropylar half of the embryo-sac, close to the synergidæ or ovum; in 29^b the nuclei have not as yet come in contact; in 29^c they are markedly flattened off against one another, and in 29^a the two nucleoli have come into contact. In fig. 30 the embryo-sac is seen to be lined by a thick layer of protoplasm, sending strands and columns to the conjugating nuclei; while in fig. 31, after the fusion of the nuclei, the main bulk of the protoplasm is aggregated round the newly formed primary endosperm-nucleus, comparatively little protoplasm remaining in contact with the wall of the sac.

Let us study next the details of this conjugation of nuclei resulting in the formation of the primary endosperm-nucleus; figs. 30–43 illustrate the process as it occurs in *Myosurus*, and figs. 45–47 show a few steps of the conjugation in *Scilla nutans*. The latter plant, being a Monocotyledon, has large nuclei, the details of whose structure are more readily made out than in the comparatively small nuclei of Dicotyledons. The preparations of *Scilla* were made by me in the Laboratory of the Royal Botanic Garden by my picro-corrosive method for Professor Bayley Balfour while acting as his Assistant.

After the micropylar and the antipodal nuclei have come in contact with one another, we see, in hæmatoxylin-preparations (fig. 32), each nucleus enclosed by a very delicate, feebly-stained envelope, the nuclear membrane (*n. m.*), the inner surface of which lies in direct contact with the chromatin-granules (*chr*) of the nucleus proper. Within the nucleus lies a large deeply-stained nucleolus (*nll.*) enclosed by a very faintly-stained nucleolar membrane (*nll. m.*).* The protoplasm of the nucleus seems to be divided into a peripheral darker (*1*), and a perinucleolar fainter (*2*), portion. This appearance of the nucleo-hyaloplasm may be really indicative of the normal structure of a nucleus, as Frommann points out, or may be in this instance simply an artificial product, brought about by a separation and retraction of the fibrils of the nucleo-hyaloplasm from the nucleolar membrane, due to my imperfect method of fixing. But even if this

* The nulcleolar membrane has not been represented in fig. 32.

area be an artificial product, it will help us in our study, for on account of differences in the tension, arrangements, &c., of the fibrils of the hyaloplasm during conjugation, the latter must assume various shapes in retracting when acted upon by the same medium.

Still studying the fig. 32, we find within the micropylar nucleus (*M. N.*) two homogeneous, globular bodies (*p. n.*) with a dark centre, and one similar body in the antipodal nucleus (*A. N.*, *p. n.*). In addition to these three globular bodies a number of homogeneous bodies (*m*) flattened out against the nuclear membrane (*n. m.*) are seen in both nuclei. The globular bodies seem to originate thus: When the nuclei about to conjugate have come in contact, one or two small nucleoli arise by the unequal division of the primary nucleolus (fig. 45, *p. n.*, in the micropylar nucleus of *Scilla nutans*). These secondary nucleoli seem to have at first the power of division, but gradually they lose this power and their property of becoming deeply stained, and change into globular colloid-looking masses with a central more deeply-stained spot. I propose to call these bodies paranucleoli because of their origin, they may always be found in the micropylar nucleus and occasionally also in the antipodal nucleus (figs. 32, 33 (35 ?), 36, *p. n.*). Fig. 33 shows two nuclei flattened against one another with the approximated sides appearing as an oblique septum. In fig. 34 the septum runs across the conjugating nuclei at right angles to their long axes, and it has begun to give way in the centre (*f*), a point corresponding to those parts of the two nuclear membranes which first come into contact with one another, and which therefore have been able to react upon one another for the longest time.

The perinucleolar hyaloplasms (fig. 34) of the two nuclei have just come in contact, and are seen to have apparently fused in fig. 35, as the septum is still more absorbed. On the left of the same figure two bodies (*p* ?) are seen, which may be paranucleoli, and which are separated by the septum. The next step in the conjugation is an approximation of the two nucleoli brought about by the antipodal nucleolus travelling towards the micropylar one (fig. 36[a]). It almost seems to have crossed the line where one would have expected to find the septum in the earlier stages of conjuga-

tion. An actual fusing of the two nucleoli is seen in fig. 36[b]; they have met in the micropylar end of the already fused nuclei, and this formation of the new nucleolus has been completed in figs. 37, 38.

Synchronously with the blending of the two nucleoli into the nucleolus of the primary endosperm-nucleus a new structure makes its appearance. This body (*n. b.*) is seen in figs. 37–43, and corresponds, I believe, to the nucleolar membrane of the antipodal nucleolus. It usually lies in close contact with the nuclear membrane of the primary endosperm-nucleus, and shows, in its earlier stages, a finely dotted or granular appearance, but gradually becomes more homogeneous looking. I should have traced its origin more minutely but for the rapidity with which the two nucleoli fuse. This fusion occurs so rapidly that the preparation from which fig. 36[b] was drawn only came into my possession after two years of patient searching. The newly formed nucleolus gradually descends towards the antipodal half of the endosperm-nucleus and ultimately occupies its centre (figs. 37–44).

Before attempting to give an explanation of the phenomena of fertilisation as seen during the act of conjugation, an explanation bound up as it is in a knowledge of the minute structure of the nucleus and nucleolus, let me briefly summarise the stages in the formation of the endosperm-cell, as follows:—

1. Amœboid movements of the cell-plasmata of the two primordial cells leading to conjugation of the cell-plasmata.
2. Approximation of nuclei and formation of para-nucleoli.
3. Flattening of nuclei on contact, and absorption of intervening nuclear membrane.
4. Conjugation of nuclei.
5. Approximation of nucleoli.
6. Conjugation of nucleoli and casting off of (male ?) nucleolar bag.

Yet another body or bodies are seen a short time after the completion of the conjugation, for we find in fig. 38, two bodies x and y, of which the former is clear and hyaline,

possessing a granular border, while the latter seems to be a colloid mass stained by hæmatoxylin. In fig. 40[a], one large body (?) is partly covered by the nucleolar bag (*n. b.*). Two minute bodies each with an ill-defined central feebly-stained spot are shown in fig. 41 towards the basal end of the nucleus, while towards its micropylar end a number of spherical bodies, each with a dark central spot, occur, two of which (perhaps a third one on the left side) are outside the nucleus, while two are within the nuclear membrane. Fig. 31 evidently shows a primary endosperm-nucleus with a large nucleolus in its upper half and a number of globular bodies, each with a central deeply-stained spot in its lower half. These globular bodies almost seem to have arisen by division of the large body (?) shown in fig. 40[a]. Fig. 39 may perhaps throw some light on the manner in which the globular bodies with a dark centre get outside the nuclear membrane, for we see three very distinct spherical bodies lying outside the nucleus at its micropylar end, and a clear strand (k) running from them to the nucleus. A number of indefinite bodies (x ? and y ?) are seen close to the basal end of the nucleus. How these bodies arise I am unable to say, they may have some connection with the paranucleolar bodies (*p. n.*, figs. 32, 33, 35, 36[b]), as fig. 35 would make me incline to believe, for here we find two bodies very like paranucleoli lying in close contact with one another and only separated by the disappearing septum of the nucleus.

Whether these paranucleoli of two different nuclei have the power of conjugation just as the nucleoli have, I shall endeavour to find out, as soon as I have more time at my disposal; but a plant with larger nuclei than *Myosurus* will have to be taken for examination.

These bodies outside the nuclear membrane I saw first in September 1890, but was unable to explain them, but now I believe them to be identical with the paranuclei of Von la Valette St George, or the "sphères attractives" of v. Beneden, or the "Centrosomata" and "Archoplasm" of Boveri, or O. Hertwig's "Polkörperchen,"* or the "directing bodies" of English authors,† or v. Tieghem's "Tinoleucites."

* Max Schultze's Archiv. f. mikroscop. Anat. xxxvi., 1890, p. 29.

† "Polar bodies" of English authors correspond to the "Richtungs-körper" (*i.e.*, directing bodies) of O. Hertwig.

MINUTE STRUCTURE OF NUCLEI AND NUCLEOLI.

Let us next study the minute structure of nuclei and nucleoli, by beginning with fig. 45, which shows two nuclei of *Scilla* just commencing to conjugate.

Both nuclei are surrounded by a comparatively thick unstained nuclear membrane (*n. m.*), having a refractive index almost the same as that of turpentine-balsam. This membrane is traversed by a number of radial pores which are visible, because they contain a substance which has a less-high refractive index than the nuclear membrane. Lining the inner aspect of the membrane are a number of irregularly lenticular-shaped chromatin-elements (*chr. 1*), which may or may not be in communication with one another by means of fine strands of chromatin, and which often are arranged as the beads of a rosary. The difference, in their thickness, as shown in the figure, is only apparent, for the chromatin-plates being arranged in a globular fashion, will not be all in focus at the same time. In addition to these peripheral somata (*chr. 1*), a number of more or less central ones (*chr. 2*) are arranged along nuclear threads ($n. f.^1$) which pass from the nuclear to the nucleolar membrane (*1*). Some of the threads are distinctly tubular, and show a double outline (*n. f.*), while others are either too minute to be recognised as tubes, or perhaps consist of solid strands ($n. f.^2$). Working even with the very best appliances, and taking every precaution, I have found it sometimes impossible to trace a filament along its entire length, and it is just possible that, what I describe as solid strands, corresponds to the anastomosing branches connecting the chromosomes with one another.

Surrounding the nucleolus is a nucleolar membrane (*1*), fainter, and of a higher refractive index than the nuclear membrane. Similarly as in the nuclear membrane, a number of very minute dark radially-placed pores or striæ can be observed, and on careful focussing it is possible to see that these striæ are continued into very delicate cilia-like fibrils (*5*) radiating out from the nucleolar membrane into the nuclear hyaloplasm (*n. h.*). The fibrils are not stained by hæmatoxylin, and are only visible because of their refractive index being lower than that of the nucleo-hyaloplasm.

The nucleolus (*3*) is differentiated into an outer zone and an inner zone. The outer zone is less deeply stained, and on careful examination is found to be made up of a circle of peripheral endonucleoli,* which are slightly elongated radially. The inner zone of the nucleolus is very darkly stained, and shows a number of large and irregularly disposed endonucleoli (*4*).

Fig. 46 is very similar to the figure preceding it, but in addition it shows a paranucleolus (*p. n.*) in the upper nucleus; the septum of the nucleus thinner in the middle, and wavy, still unbroken, however, and separating therefore the peripheral chromatin-granules; and only one large central endonucleolus in each nucleolus, and a finely granular area in the upper nucleolus.

For a full account of the literature on nuclei, I must refer the reader to two excellent papers by Courchet and v. Bambeke. Courchet † has specially referred to the early literature on the endonucleoli, and has given a short *resumé* of papers by Flemming, Leydig, Hessling, Lacaze-Duthiers, O. Hertwig, Schrön, J. M. Macfarlane, and Frommann. Von Bambeke ‡ has treated very systematically the various nomenclature introduced by the different masters in cell-study, and has also devoted special attention to the endonucleoli, giving the views of Flemming, Frommann, Leydig, Carnoy, van Beneden, and himself.

Fig. 47 represents the nucleolus of a micropylar primordial cell after the formation of a paranucleolus. The remarkable fact is a radial striation (*r. f.*) of the nucleolar chromatin-matter, and although the striation is by no means very distinct, I believe this figure to fill a gap which exists in figs. 45 and 46, as we shall see afterwards.

In how far can we corroborate these observations in *Myosurus*:—

The resting nucleolus of the sporocyte, or embryo-sac-cell (figs. 9^a, 11, 13^a, 13^b, 14) displays a large central unstained

* Various terms have been used and are still in use referring to the unstained areas in the nucleoli, such as "the granule of Schrön," or "nucleololus," or "nucleolo-nucleus," or "vacuoles," and I propose therefore to use the term "endonucleolus," which was suggested to Dr Macfarlane by Professor Rutherford ten years ago.

† Lucien Courchet, Du Noyau, Paris, 1884.

‡ Von Bambeke, Structure du Noyau Cellulaire à l'état de Repos, Gand, 1885.

area, the central endonucleolus, and a great number of minute oval unstained points close to its periphery, the peripheral endonucleoli. A similar appearance is shown by the nucleolus of the primary endosperm-nucleus, fig. 31.

In fig. 44[a], representing the primary endosperm-nucleus some time after its formation, a large nucleolus is seen with a number of minute structures, which have been diagramatically represented in fig. 44[b], namely:—

1. A thin unstained nucleolar membrane.
2. A great number of peripheral endonucleoli.
3. A deeply-stained, apparently structureless, layer.
4. A corona of minute, slightly elongated, endonucleoli surrounding.
5. A large central endonucleolus.

Fig. 43[a], 43[b]. The nucleolus has been represented amplified in 43[b], and is made up of:—

1. An unstained nucleolar membrane (*nl. m.*).
2. A not very deeply-stained submembranous area traversed by radiating filaments (*r. f.*).
3. A very deeply-stained portion, with four comparatively large endonucleoli at its central border (*x*).
4. A large number of small radially-elongated endonucleoli (the proximal ones).
5. A large central endonucleolus surrounded by an annular outbulging or fold (*fold*).

Figs. 41 and 42 are very similar to fig. 43, for in fig. 41 we find a large central endonucleolus with a highly refractive plate-like body (*plate*), surrounded by seven small endonucleoli of varying diameter. The nucleolus being rather deeply stained further details could not be made out. Fig. 42 shows again the large central endonucleolus (*4*) surrounded by a number of minute endonucleoli smaller and less numerous than those in fig. 43. The body (*5*) corresponds to one of the endonucleoli marked (*x*) in fig. 43. A nucleolar membrane could again be made out, but nothing further.

The stages, figs. 41 to 44, are very near one another, but any connection between them and the figures preceding them I have not been able to make out as yet, and I shall trace

the stages of the formation of the primary endosperm-nucleus gradually backwards to the best of my ability.

The nucleolus of fig. 40 contains a number of spherical endonucleoli, perhaps arranged as the beads of a rosary. Those endonucleoli marked with an x seemed to touch one another, although they were lying at different levels, while the uncrossed areas were placed so deeply that I could not convince myself definitely as to whether they formed a chain or not. This one nucleolus cost me three days hard work, as sketches of the endonucleoli had to be made again and again, after revolving the stage, changing the light, &c., &c.

The nucleolus, fig. 39, is surrounded by a nucleolar membrane which seems to be bulging out at the micropylar end, and leading apparently to the directing bodies (*dir. b.*). Several larger and smaller endonucleoli are arranged in a line across the nucleolus.

Figs. 38, 37, show respectively four small and one large, and four small and two large, endonucleoli.

In fig. 36^b, illustrating the act of conjugation of the two nucleoli, both of these are seen to be enclosed by a membrane. The micropylar nucleolus contains two large endonucleoli embedded in nucleoloplasm which has a mottled appearance, while the antipodal nucleolus shows an indistinct spongy appearance.

In fig. 36^a both nucleoli have nucleolar membranes; the micropylar one contains three, and the antipodal one contains nine endonucleoli.

The nucleoli in fig. 35 show again a set of peripheral small endonucleoli, and, respectively, one and two excentrally placed large endonucleoli.

Figs. 34, 33, 32 show large nucleoli with ill-defined endonucleoli.

We learn thus from figs. 9^a, 11, 13^a, 13^b, 14, 31, 35, 41–47, that the nucleolus possesses a very complicated structure, and I have endeavoured to bring the details together revealed by the different nucleoli, nuclei, and cell-plasmata, and have constructed fig. 48 to illustrate my conception of the achromatin of a normal highly-developed cell.

A cell may be divided into three zones—a nucleolar or intra-nuclear (*6*), a nuclear (*4*), and an extra-nuclear (*2*) zone, which latter forms the "body" of the cell. These

three parts are separated from one another by the nuclear (*3*) and nucleolar (*5*) membranes, membranes which are, as has already been pointed out, probably the inner denser areas of the body-plasm and nuclear plasm respectively, and which do not correspond to the outer denser parts of the nucleolus and nucleus.

In the same fig. 48, two sets of strands or fibrils have been represented, one set as dark lines radiating from the centre of the nucleolus, *i.e.*, from the central endonucleolus (*a*); and a second set as dotted lines radiating from two paranuclei (*m*) just outside the nuclear membrane.

Let us study next the endonucleolar plasm more minutely (fig. 48).

In a resting cell, *i.e.*, a cell not about to undergo either division or conjugation, the centre of the nucleolus is occupied by a large endonucleolus (*a*), which sends out minute fibrils (*c*) through the nucleolar substance (*6*). Each fibril has a proximal (*b*) and a distal (*d*) swelling, and the proximal swellings of the various fibrils form conjointly a corona surrounding the central endonucleolus, while the distal swellings give rise to a light area just internal to the nucleolar membrane. From the distal enlargements the endonucleolar fibrils pass through the peripheral nucleolar area, and then through the nucleolar membrane into the nuclear achromatin.* Here they may be recognised, as they possess a lower refractive index than the turpentine-balsam.

On turning to fig. 45 we find a large number of pores in the nuclear membrane, most of which differ, however, from the nucleolar pores in being much larger (*p. a*), a fact which could be accounted for in several ways, either the endonucleolar fibrils (which I have represented as passing through the nuclear membrane in fig. 48) receive an envelope of nuclear achromatin, or the endonucleolar fibrils undergo an increase in thickness in the nuclear area, or perhaps the larger pores in the nuclear membrane (figs. 45, 46) are for the transmission of structures other than endonucleolar ones, structures which may pass either from the cell-plasm to the nucleus or in the opposite direction. In this

* Synonyms: Kernsaft (O. Hertwig); Zwischensubstanz, Achromatin (Flemming); Karyochylema (Strasburger); Paralinin (Waldeyer).

case I believe the endonucleolar fibrils probably to pass through the finer pores in the nuclear membrane (*p.* β fig. 48).

The fibrils have been represented in the diagram as sending branches to the achromatic network of a chromosome (*chr.*) before they pierce the nuclear membrane, and, after they have entered the cytoplasm, to form anastomoses, and ultimately to project through the cell-wall, either to communicate with similar fibrils originating in the endonucleoli of neighbouring cells, or with the medium surrounding the cell in question.

What relation the tubular nuclear filaments (fig. 45, *n. f.*), along the sides of which the central chromosomes occur, have to the endonucleolar filaments I was unable to make out, but as the number of the nuclear strands is comparatively very small, while the endonucleolar filaments occur in large numbers, I am inclined to believe that these two sets of strands exist independently of one another in the nucleus, meaning by the term independent, that each of the main strands pursues its own course, having special functions to fulfil.

In what way the nuclear "chromatin" is governed by the endonucleolar matter I was unable to make out, but conjecture that the endonucleolar filaments constitute the linin element of the chromosomes, a hypothesis which would allow us to understand how the chromosomes are influenced by the endonucleolar matter.

Quite recently Fayod* has written a paper on the structure of living protoplasm. By both injecting vegetable and animal cells with powdered indigo or carmine, and by allowing cells to absorb these substances *intra vitam*, the author has come to the following conclusions:—

The "hyaloplasm" of Hofmeister, de Bary, Leydig, or "paraplasm" of Kupfer, or "chylema" of Strasburger, the "interfilar Substanz" or "paramitom" of Flemming, the "interfilar Substanz" of Altmann, &c., consists of a reticulated framework of strands called "spirospartes," each of which shows two spiral tubes or "spirofibrilles" surrounding a central axis-cylinder, which latter also possesses a spiral structure.

The spirofibrilles equal in diameter the *Spirillum tenue*,

* M. V. Fayod in Rev. Gén. de Bot. (Bonnier), iii. (1891), pp. 193–228, pl. xiv.

and are believed to be built up of still finer spiral tubes. One of the two spirofibrilles in each spirospart serves for the upward conduction, while the other serves for the downward conduction of plastids, and the author says he has been even successful in seeing the plastids move along the hollow spirofibrilles. These plastid substances we are in the habit of staining with our ordinary histological methods, the walls of the spirals taking on no stain. Vacuoles are further believed to correspond to enormously dilated spirofibrilles, and the nucleus to be the meeting point of several spirosparts.

I am as yet unable to criticise these views of Fayod, but shall do so fully as soon as I have repeated the various experiments described in this highly interesting paper. Simply judging by the illustrations (figs. 1, 2, 3, 4), I would be inclined to say that spirofibrilles exist, but certainly I would not be able to construct from these four figures the diagrams figs. 6 and 7.

To return to fig. 48. External to the nuclear membrane (*3*), two paranuclei (*m*) have been figured as lying close to one pole of the nucleus, and sending branches to the nucleolar (*p*), nuclear (*o*), and extranuclear (*n*) achromatin.

Two paranuclei (*m*) have been figured, as according to Flemming* and Guignard,† two bodies are usually, if not always, to be found in a resting cell. Each paranucleus consists of a "central body" (v. Beneden), surrounded by a pale area—the "attractive sphere" (v. Beneden) [Boveri's "centrosome" and "archoplasm" respectively]. The "attractive sphere" is represented as sending out filaments in all directions.‡ The archoplasm of paranuclei does not consist, however, of a homogeneous mass, for Platner § says that the paranucleus of the resting spermatocytes of *Helix pomatia*

* W. Flemming, Neue Beiträge z. Kenntniss d. Zelle, in Archiv. f. Mikrosc. Anat. xxxvii. p. 701.

† L. Guignard, Sur l'existence d. "sphères attractives" dans les cellules végétales, in Comptes Rend. Ac. d. sc. Paris, 9 Mars 1891.

‡ The best stain for the centrosome is, according to Flemming (Archiv. f. Mikr. Anat. xxxvii. p. 686) orange G. [(the sodium salt of anilin-azo-β-naphtal disulfosäure) Grübler]. Hermann (Archiv. f. Mikr. Anat. xxxiv. and xxxvii. pp. 571, 583) uses his platino-chlorid-osmo-acetic mixture, with subsequent reduction of the osmium by wood-vinegar, or—a modification of Pal's hæmatoxylin.

It was in sections stained with Kleinenberg's No. 1 hæmatoxylin, and decolorised in bismarck-brown, that I first observed these bodies, three years ago.

§ Archiv. f. Mikrosc. Anat. B. 26 and 33.

contains a coiled filament, which, at the commencement of division, breaks up into six (*Helix*) or eight (*Limax*) rods; that these in their turn divide longitudinally, move asunder, and form the chief rays of the polar radiation. Prenent * saw also ribbon-shaped filaments in the sphères attractifs, and considers them as rudimentary forms of the paranuclei. Hermann † has seen twelve crescentic filaments in *Helix*, and also groups of short S-shaped or looped filaments surrounding the "central body" in the spermatocytes of *Proteus anguineus*.

Hermann has further, † in his description of the spermatogenesis of the Salamander, pointed out that in the paranucleus a globular body (the middle piece of the ripe spermatozoon) is stained red by saffranin, while a ring-like body (the spiral membrane on the tail of the mature spermatozoon) is stained violet by gentian-violet. In the same paper a method of differential nucleolar staining is given, namely, the nucleoli red, by saffranin, and the rest of the cell violet, by gentian-violet, in resting cells, while during division monasters and diasters are stained red, and everything else stained violet.§ The author, besides mentioning the facts of the differential nucleolar staining, and that a part of the paranucleus is stained violet while another part is stained red, has either not deemed it prudent to draw a comparison between the staining reactions of the nuclei and paranuclei, or has overlooked the fact.

I believe the fact just stated, that it is possible to stain the paranucleus analogously to the nucleus, to be of the

* La Cellule, IV. 1.

† Archiv. f. Mikrosc. Anat. 37, p. 585.

‡ Hermann, Hodenstudien' in Archiv. Mikrosc. Anat. xxxiv.

§ Guignard was the first to put on record a method for differential nucleolar staining with methyl-green and fuchsin, or with hæmatoxylin and saffranin, in 1885 [Ann. Sc. Nat. sér 6, T. xx. p. 318]. Hermann comes next with his saffranin and gentian-violet method, in April 1889 [Archiv. Mikr. Anat. xxxiv. p. 60]. I then published an account in Jan. 1891, Trans. Bot. Soc. Edinb., showing that differential stains might be produced by heliocin and methylene-blue, or eosin (erythrosin) and methylene-blue, or nigrosin and eosin, or nigrosin and hæmatoxylin.

Flemming, in his latest paper, Neue Beiträge z. Kennt. d. Zelle, 24th April 1891, Arch. Mikrosc. Anat. xxxvii. p. 697, says that he demonstrated double stains as far back as 1884, at the Kopenhagen Medical Congress, and that since that time he has frequently demonstrated the same phenomenon. Flemming uses for differential staining, saffranin, hæmatoxylin, saffranin-mannein, or saffranin-gentian-violet.

It is evident that I knew of Guignard's method, but not of Hermann's; that Hermann and Flemming also, quite independently of one another, made the same observations as to the different behaviour of the nucleolar and nuclear matters in regard to staining reagents.

highest importance, and specially in combination with the other fact that the paranuclei have a nuclear origin, as pointed out above, and as also believed by Hermann, who, in the same paper, p. 88, states that the paranucleus is, in all probability, derived from the interior of the nucleus as an originally non-stainable body. These various facts seem to justify us in considering the paranuclei as diminutive nuclei.

Amongst botanists, Guignard * pointed out the presence of paranuclei, or, as he calls them, "attractive or directing spheres," in vegetable tissues, *e.g.*, in the primordial mother-cells of the pollen of *Lilium*, *Listera*, *Naias*, and in the mother-cell of the embryo-sac, and confirms the observations of zoologists as to the part they play in cell division. Wildeman † confirms Guignard's observations, and states that very typical paranuclei are found in *Spirogyra nitida*, and that they also occur in the mother-cells of the spores of *Anthoceros lævis* and *Isoetes Durieui*, further in *Funaria hygrometrica*, *Ceratodon purpureus*, and *Bryum cæspitosum*. Van Tieghem ‡ proposes to call the paranuclei the "directing leucites," or tinoleucites.

WHAT IS KNOWN ABOUT THE FUNCTIONS OF THE NUCLEUS, THE NUCLEOLUS, AND ENDONUCLEOLUS ?

To attribute to these organs the "functions" of fertilisation and division is impossible, as both fertilisation and division must be regarded only as phenomena in the life-cycle of a cell, determined by factors injurious to the maintenance of the individuality of each cell. To put it differently :—

Each cell once formed will endeavour to develop and to retain its individuality as long as extrinsic and intrinsic agencies will allow it to do so. Should, however, the equilibrium existing between the various organs of a cell be upset, an equilibrium necessary for the normal fulfilment of the different physiological functions, then, if the cell be not killed outright, a tendency to restore the disturbed equilibrium may lead, on the one hand, to the division of a cell, or, on the other hand, to the conjugation of two

* Comptes Rend., cxii. (1891), pp. 539–42.
† E. De Wildeman, in Bull. Acad. Roy. Sci. Belgique, lxi. (1891), pp. 594–602.
‡ P. Van Tieghem, in Journ. de Bot. (Morot) v. (1891), pp. 101–2.

cells. Division and conjugation, however, will put a stop to the individuality of the cell in question, but though such has been lost, yet the individuality of the plasms constituting the cell has been preserved, and it is this maintenance of an individual plasm which, though it lead to the loss or death of individual cell-life, yet serves to perpetuate the species.

As the various organs of a cell, we may consider the endonucleolus, the nucleolus, the chromatin and achromatin of the nucleus, the chromatin and achromatin of the cytoplasm, the various plastids, the paranucleus with its chromatic and achromatic elements, and the cell-wall. Each of these structures will have to fulfil definite functions, and probably such functions as the different organs of a highly developed animal or plant perform. We must localise in a cell the channels in which the unelaborated food travels, organs which will act on the food, organs which will distribute the elaborated material, organs for respiration and secretion, and a centre which acts as a trophic centre. Such a centre would be the seat of the essential plasm of a cell, the plasm which stamps a cell with the character of its species, which is the common bond for the various organs, which regulates income and expenditure, and which, through its organs, becomes modified itself.

In such a plasm would be contained the principle of life, and well we might call it the "psychoplasm" of a cell.

What is known about the various functions of the nucleus has been brought together by Hofer * in an admirable paper. The author, after referring to work done by K. Brandt, Nussbaum, Gruber, Verworn, Balbiani, Schmitz, Klebs, Haberlandt, Korschelt, gives a very lucid account of his experiments on *Amœba proteus*, which led him to the conclusions that the nucleus, firstly, possesses a direct influence over the movement of the protoplasm, inasmuch as it is a regulating locomotory centre; and that, secondly, it influences the digestion, as only by the co-operation of nucleus and protoplasm a secretion of digesting fluids is possible; that further, thirdly, the nucleus is neither concerned in respiration; nor, fourthly, in the control of the contractile vacuole.

* B. Hofer, Einfluss, d. Kernes auf d. Protopl., in Jenaisch. Zeitschr. für Naturwiss., Bd. xxiv., Nov. 1889.

Verworn * holds, however, that a nucleus has nothing to do with the movements of the body-plasm, and believes enucleated masses of plasm to perform exactly the same movements as nucleated masses do.

Eimer † considers the nucleus in general as that organ of the cell which originates and governs the processes of life, and believes it to act in unicellular animals as a central nervous organ, and points out that also in the higher animals the nucleus plays a very important part as a centre of nerve-force, for in ganglion-cells the nuclei reach an enormous size; in *Beroe* a nerve-fibril may be traced from the nucleolus of one nucleus to the nucleoli of all the other nuclei which lie on the road of the fibril; in *Medusa* the nerve-fibres pass in the sensory cells through the nucleoli, and end ultimately in the cilia; in non-sensory cells, as muscle-cells and epidermis, the nerves terminate in nuclei; and in the nerve-cells the nerve-fibrils can be seen to radiate out from the nucleoli, and to form a fibrillar network in the nucleus.

A similar network is said to occur also in the germinal vesicle of the egg-cell, due to fibrils radiating out from the germinal spot. It is believed that these radiating fibres serve in the egg, at first, as paths of nourishment, and that later on, due to firming or the consolidation of these strands, they become transformed into nerve-fibrils.

The author further states that these strands correspond to Weismann's idioplasm, *i.e.*, to that firm substance which conveys the characters of the species from generation to generation.

Brass' ‡ book I have not been able to procure, and am therefore unable to state which views are held by the author.

Fayod, in the above quoted paper, I understand to have made out that the hyaloplasm (Hofmeister) of a cell serves as the condenser of oxygen, *i.e.*, that it plays the part of a respiratory organ, and that of the two spirofibrilles surrounding each axis, one serves as a conductor of elaborated material, while the other is a channel for unelaborated substances.

* Verworn, Psycho-physiologische Protistenstudien, Jena, 1889.
† Organic Evolution, 1890, Engl. Transl., p. 349.
‡ Brass, Die Zelle das Element d. organischen Welt, Leipzig, 1889.

Strasburger gives it as his opinion that the formative processes of the cell are regulated by the hyaline plasma of the nucleus, the nucleo-idioplasm (chromatin of Flemming), and believes that the greater the amount of this idioplasm, the more readily does the division of a cell take place.

R. Hertwig * also considers the chromatin of the nucleus to be the most essential factor in the cell, and the carrier of hereditary tendencies, and the achromatin only to play a part in cell-multiplication (p. 52).

The function of the nucleolus, according to Flemming, consists in the latter acting as a special reservoir for the reproduction and accumulation of chromatin.

Strasburger considers the nucleolus to be a mass of reserve-material for the nucleus, and to take no part in the functions of the nucleus.

Pfitzner believes the nucleolar chromatin during division to become transformed into nuclear chromatin, and therefore proposes to call the nucleolar substance "prochromatin."

Carnoy holds that the nucleoli form a mass of reserve-material for the nuclear plasma, *i.e.*, that just as the protoplasm uses up its deposits, so does the nucleus use up the nucleoli.†

Some facts which came under my own notice are shortly these:—(*1*) Actively budding yeast washed in distilled water to remove all sugar, killed and fixed by my picro-corrosive alcohol, washed and then stained with Ehrlich's acid hæmatoxylin, eythrosin, or eosin, shows in the youngest buds a deeply-stained granule, which may be either a nucleolus or a nuclear chromosome. This constant occurrence of a deeply-stained granule suggests that it may be the cause of the budding, *i.e.*, of the change in the wall of the mother-cell.

(*2*) A comparison of the relative position of the nucleus and vacuole in the synergidæ, and the ovum shows, as has already been suggested, that the synergidæ receive their food-supply from the apex of the ovule, while the ovum receives its nourishment from the basal part of the embryo-sac.

(*3*) In transverse sections of chick-embryos, 48–60 hours old, fixed by my method, it is constantly found that in the individual cells, the nuclei are lying in that part of the cell

* R. Hertwig, Lehrbuch d. Zoolog., 1891.
† Van Bambeke, pp. 59, 60.

nearest the yolk, and that in the nuclei the nucleoli are lying in the direction of the source of food-supply.

Facts 2 and 3 point out evidently that the nucleus and nucleolus are concerned in the assimilation of food-material. They may, indeed, only owe their partial stainability to the fact that they serve as store-houses of highly elaborated albuminoid materials, materials which will be converted into the still higher achromatic elements of the cell. This suggestion seems to be highly probable if one takes Hofer's experiments into account, which showed distinctly that albuminoid materials, taken up by an amœba, the more they are elaborated, *i.e.*, digested, the deeper they are stained by a dilute bismarck-brown solution. These observations, conducted by staining amœbæ, or rather their food-supply *intra vitam*, are of the very highest physiological importance.

(*4*) In following out the history of the parasitic embryo-sac, we found that all the cells in the mature sac, with exception of the three antipodal cells, show a feeble development of the nuclear chromatin, the nucleolar and the achromatic element predominating evidently. This may, perhaps, have its reason in the antipodal cells being to a less degree parasitic than their sister-cells, as they lie next the plerome, and receive probably less elaborated nourishment through this channel than the synergidæ, ovum, and endosperm-cell, which, for their supply of nourishment, depend on the death of the nucellar cells surrounding the sac.

If my view be correct, then what I have stated under fact 3, in conjunction with Hofer's experiments, would show the nuclear chromatin to be a less highly elaborated and less assimilative albuminoid material than the nucleolar chromatin.

(*5*) On the assumption just stated, we could explain also why we find in the parasitic cells of the embryo-sac, at the time of maturation, portions of nucleolar matter detaching themselves from the main nucleolus to undergo a peculiar gelatinous change. The gelatinous change would correspond to a conversion of the assimilative material into achromatic elements, an explanation which would also explain the disappearance of nucleoli during the division of a cell. The fragmentation of the nucleoli, on the other hand, would correspond to a division of the achromatic element of the

nucleolus, *i.e.*, the endonucleolus, brought about by the large amount of directly available food-material.

It is thus evident that I have not been able to assign definitely any special functions to either the nucleus or the nucleolus, but I believe the hypothesis that the nuclear chromatin-segments and perhaps the nucleoli are organs for the conversion of assimilated material into material directly available for the achromatic elements of the cell, to be not quite erroneous.

What the function of the paranuclei may be is not known as yet. They play a very important part during the division of the cell, a fact I have already alluded to. For a summary of the recent literature, I must refer the reader to Flemming.*

Not only during division, but also during fertilisation, the paranuclei have been shown to be active by Fol and Guignard, to whose researches I shall refer when I speak about the phenomena of fertilisation. My assumption that the paranuclei may be concerned in exerting a trophic influence on the nuclei is based on the phenomena of nuclear division, as I have already explained, but whether they have any other function I am unable to say, and would only warn the reader not to take a teleological view, by considering paranuclei to have been developed for the purposes of nuclear division or cell-conjugation.

To consider the functions of the achromatic parts of a cell would be our next task.

From my description of the conjugation of the two primordial cells, the reader will have gathered, how, the definite structure of the nucleolus is lost more and more as we approach the act of fertilisation, and, how, after the completion of the act, a new nucleolus results with a structure similar to that of either individual nucleolus before fertilisation, a structure, which I have diagrammatically represented in fig. 48, showing a central, proximal and distal endonucleoli and radiating fibres.

This endonucleolar matter permeating the nucleolus, the nucleus and the cell seems to be the trophic centre for all the organs concerned in assimilation and dissimilation. It is

* Flemming, Neue Beiträge z. Kenntniss. d. Zelle, in Archiv. f. Mikros. Anatomie, xxxvii. p. 701.

this plasm which plays so important a part in the conjugation of cells, and how it does so I have represented in figs. 50, *a–g*.

Describing simply the mechanism of conjugation, I believe it to take place thus:—The endonucleolar fibrils running through the body-plasm of the two sexual cells (in the centre of the embryo-sac) are brought into contact with one another whenever the pseudopodial processes of the two cells have met. As soon as a union of fibrils has taken place, each fibril will commence to contract similarly to a muscular fibril, with the result that the two nuclei are gradually brought together; that they become flattened off against one another, because of the resisting nuclear membrane; that the nucleoli become flattened off because of the nucleolar membrane, and that, ultimately, fusion of the two endonucleolar plasms occurs. During this conjugation, in all probability, we have no "fusion" of analogous cell-elements of the two conjugating cells, *i.e.*, we have the individuality of the corresponding organs, *e.g.*, the chromatin-elements retained.

If the view just stated be correct, that, namely, the endonucleolar matter has the power of bringing cell-plasms, nuclei, and nucleoli together, probably because of its intimate union with these different organs, and because of its contractility, and if the paranuclei (v. La Valette St George) are similar in structure to the nuclei, *i.e.*, if they too contain a plasm corresponding to the endonucleolar plasm of the nuclei, and if this plasm is permeating amongst other organs, also the structures within the nuclear membrane, then many difficulties could be explained, which I, without such a hypothesis, cannot explain.

Given then in a cell, firstly, a nucleus with a trophic centre for the whole cell, namely, the endonucleolus; and, secondly, an extra-nuclear structure—the paranucleus—with a trophic centre for the nucleus; and, thirdly, an attachment to or union of these two trophic-centre-filaments with the various nuclear elements, then we could understand how, in a resting-cell, the intra-nuclear centre may influence the various cell-structures in such a way as to arrange them concentrically round itself.

Should, however, by any means the trophic influence of the intra-nuclear centre be weakened, and a corresponding

weakening not occur in the extra-nuclear centre, then the latter will be able by its filaments to exert a stronger pull on the various nuclear elements, and arrange these round its own centre, or rather two centres, as normally two para-nuclei can be found in a resting-cell. In attracting the nuclear elements, I would expect the extra-nuclear centre to affect, firstly, the essential intra-nuclear trophic centre, and only, secondarily, the chromatin-segments, &c. That such a hypothesis as just propounded, is not only possible, but highly probable, seems to be proved by F. Hermann's figures and description * of cell-division, which the author has studied in the spermatocytes of *Salamandra maculata.* During the resting condition of the cell a mass of "archoplasm" is to be found near the nucleus, sending indistinct fibrils into the body-plasm of the cell, but not showing a centrosome. (This body has been, however, observed by the same author in the spermatocytes of *Proteus anguinis.*) During the spirem stage two centrosomes are seen, and these, as karyokinesis progresses, move asunder, remaining, however, in connection with one another by strands of very delicate fibrils. Simultaneously, the nuclear membrane is dissolved gradually, but before its complete disappearance, the chromatin-elements of the nucleus occupy a position in the nucleus diametrically opposite to the region in which the two archoplasms and the centrosomata occur. This massing together of the chromatin leads to the achromatic portion of the nucleus being brought in contact with the archoplasm, and it is possible to see the achromatic-fibrils of the nucleus running towards the archoplasm.

How this retraction of the chromatin-filaments is brought about is, of course, a difficult question, and the author, not believing in an active mobility of the chromatin-segments, suggests that at that pole of the nucleus which is in close contact with the archoplasm, the continuity between the nucleus and the body-plasm gives way first, and that through this dissolution of continuity, certain streaming movements into the interior of the nucleus are set up along the achromatic filaments, and that the streams of fluid force the chromatin-segments against the opposite side of the nucleus, where as yet the nuclear membrane is not dissolved, and

* Beitrag z. Lehre v. d. Entsth. d. Karyok. Spindel. Taf. xxxi., Archiv. f. Mikroscop. Anat. xxxvii. p. 569.

where, therefore, no continuity between the interior of the nucleus and the cell-plasms exists.

Studying the figures, an explanation has suggested itself to me different from that offered by the author, for although I share with him the opinion that the chromatin-segments are not able to change their position in a cell by themselves, I believe the achromatin of the nucleus (both the achromatin proper and the endonucleolar filaments) to be in direct communication with the centrosomes even in the resting-cell, and to have a greater affinity for the archoplasm than the chromatin-segments, and for this reason to aggregate on that side of the nucleus lying next to the archoplasm and its centrosome. Such a massing together of the achromatin must of necessity lead to the chromatin being gradually pushed to that side of the nucleus, away from the centrosome.

In conclusion, let us study shortly how male and female tendencies are impressed on a cell.

Minot's and v. Beneden's theories have been aptly called compensation theories by Waldeyer,* for Minot supposed that all body-cells, and unripe sexual cells, were hermaphrodite or neutral, and contained two opposite properties, which, in the matured egg and spermatozoon, only occurred singly.

The female element he called the thelyblast, and the male element the arsenoblast, and any cell containing only either male or female elements, the genoblast. Fertilisation or sexual reproduction was believed to occur when a thelyblast (or female cell) from one source united with an arsenoblast (or male cell) from another source; the two by their fusion forming a perfect cell, which is called the impregnated ovum.

Van Beneden suggests that all ordinary body-cells are hermaphrodite, containing two different elements which stand in a sexual contrast to one another, as during the first, as well as subsequent divisions of the fertilised egg, each daughter-cell receives an equal share of male and female chromatin-segments. If, however, every cell in the body is hermaphrodite, then the sexual cells must also contain both male and female organs, and hence, during some period of

* W. Waldeyer, Ueber Karyokinese u. ihre Bezieh. z. d. Befruchtungsvorg. Archiv. f. Mikrosc. Anat. xxxii.

its development, the egg-cell has to get rid of its male element, and the spermatozoon of its female element. We have just seen that Minot holds the same view, but while the latter considers the polar bodies as the homologues of spermatozoa, and, therefore, as male cells, v. Beneden believes the polar bodies not to represent cells, but male nuclear structures (chromatin-segments) got rid off by a process of pseudokaryokinesis. This pseudokaryokinesis would then render the nucleus of the egg-cell of necessity unisexual and female, and such a nucleus containing only one sexual element, and unable to undergo division, he termed a pronucleus.

The nucleus being only a pronucleus, will further, of necessity, render the egg-cell an incomplete cell, incapable of division (gonocyte femelle), till by the reception of a male pronucleus the pronucleus of the egg-cell has regained its full power, and the faculty of undergoing division.*

Brooks † seems to hold that reproductive elements are the result of a division of physiological labour in different directions, but how this differentiation took place, has not been defined.

Ralph ‡ defines a male as a less nutritive and therefore smaller, hungrier, and more mobile organism; the female as the more nutritive and usually more quiescent organism, in which metabolism is more marked than in the male.

Geddes and Thompson § believe a fundamental difference to exist between "the nutritive, vegetative, or self-regarding processes within the plant or animal, as opposed to the reproductive, multiplying, or species-maintaining processes." As the nutritive changes may be resolved into constructive (anabolic) and destructive (katabolic) metabolism, and as "anabolism" and "katabolism" stand in continuous antithesis, and as further the sexual organisms (female and male) also show an antithesis, in as far as the female is inclined to passivity, while the male is inclined to activity, a parallelism between the processes of nutrition and reproduction is

* For a full account of the various theories, see the admirable paper by O. Hertwig, Vergleich d. Ei und Samenbild. b. Nematoden. (Archiv. f. Mikroscop. Anat. xxxvi. p. 1), where these theories have also been criticised.

† W. K. Brooks, The Law of Heredity, Baltimore, 1883.

‡ W. H. Ralph, Biologische Probleme, Leipzig, 1884.

§ The Evolution of Sex. The Contemporary Science Series, 1889.

suggested; "the male reproduction is associated with preponderating katabolism, and the female with relative anabolism. In terms of this thesis, therefore, both primary and secondary sexual characters express the fundamental physiological bias characteristic of either sex" (p. 27). Later, on p. 117, the following sentence occurs: "This much, however, is distinctly maintained, that future developments of the theory of sex can only differ in degree, not in kind from that here suggested, inasmuch as the present theory is, for the first time, an expression of the facts in terms which are agreed to be fundamental in biology, those of the anabolism and katabolism of protoplasm."

On pages 122, 123, we find further: "Protoplasm is an exceedingly complex and unstable substance or mixture of substances, undergoing continual chemical change or metabolism. On the one hand it is being continually reconstructed by an income of nutritive material, which, at first more or less simple, is worked up by a series of chemical changes till it reaches the climax of complexity and instability. These upbuilding, constructive, synthetic processes are summed up in the phrase anabolism. But, on the other hand, the protoplasm is continually, as it 'lives,' breaking down into more and more stable compounds, and finally into waste products. There is a disruptive, descending series of chemical changes known as katabolism. Both constructive and disruptive changes occur in manifold series. The same summit [*i.e.*, of fully formed protoplasm] may be gained or left by many different paths, but at the same time, there is, as it were, a distinct watershed,—any change in the cell must tend to throw the preponderance towards one side or the other. In a certain sense, too, the processes of income and expenditure must balance, but only to the usual extent, that expenditure must not altogether outrun income, else the cell's capital of living matter will be lost,—a fate which is often not successfully avoided. The disruptive, or katabolic, or energy-expending set of changes, may be obviously greater in one cell than in another, in proportion to the constructive or anabolic processes. Then we may shortly say that the one cell is more katabolic than the other, or *vice versa* on the opposite supposition." "Income too may continuously preponderate,

and we increase . . . . . in anabolism. Conversely, expenditure may predominate and . . . . . we may live on for a while with loss of weight, or in katabolism. This losing game of life is what we call a katabolic habit, tendency, or diathesis; the converse gaining one being, of course, the anabolic habit, temperament, tendency, or diathesis." "After what we have just said, it is evident that there are but three main physiological possibilities,—preponderant anabolism, or preponderant katabolism, or an approximate (*i.e.*, oscillating) equilibrium between these tendencies. A growing surplus of income, a lavish expenditure of energy, or a compromise in which the cell lives neither far below nor quite up to its income."

I have quoted the above sentences *verbatim*, to allow the reader to judge whether in my criticism I have, perhaps unfairly, attributed views to the authors which they themselves did not intend to express.

If the letter C represent the capital of living matter in a cell, and if A stand for anabolism and K for katabolism, then in a cell living "neither far below nor quite up to its income" (a cell intermediate between an anabolic and a katabolic cell), we might represent $C=100$, $A=20$, and $K=19$, *i.e.*, we have a slight preponderance of anabolism over katabolism, a condition which the authors believe to be essential for the existence of a normal non-sexual cell.

In a fully formed male or katabolic cell with a distinct preponderance of katabolism over anabolism, we might represent C by 100, A by 20, and K by 30, and analogously in a mature female or anabolic cell, C by 100, A by 20, and K by 10.

On comparing then a normal non-sexual cell with a male and a female cell, we would find:—

		Ultimate Capital.
Non-sexual, .	$C=100,\ A=20,\ K=19$	$=C=101.$
Male, . .	$C=100,\ A=20,\ K=30$	$=C=\ 90.$
Female, . .	$C=100,\ A=20,\ K=10$	$=C=110.$

Or, in other words, that in the male cell a reduction, while in the female cell an increase, of the original capital of living matter had taken place.

Before proceeding, it may be as well to point out that to several passages of the authors a different explanation may

be given from the one just stated, namely, that we have not an absolute katabolism in the male cell, but a relative katabolism, or if in a

Non-sexual cell, . . C=100, A=20, K=19, that in a
Male cell, . . . C=100, A=20, K=18, and in a
Female cell, . . . C=100, A=20, K=10.

This view would result in giving us at the maturity of the male cell a capital=102, and for the female cell a capital of 110, and we would have a relative anabolism of the female cell over the male cell.

That the second view just elaborated was not taken by the authors seems to be proved, firstly, by the sentences "conversely, expenditure may predominate and . . . . . we may live on for a while with *loss of weight or in katabolism.* This losing game of life is what we call a katabolic habit," &c.; and secondly, by the view stated in the chapter on the physiology of fertilisation, when the male nucleus is degraded to the position of a carrier of waste materials. But more about this latter point anon.

To return to the view I stated in the first place, and which I believe to be the author's view, that a male cell is "absolutely" more katabolic than a female cell, *i.e.*, that such a cell is spending more than it is able to take in.

Whence, then, does such a katabolic cell obtain the material for the excess of destructive metabolism? It cannot obtain it from without, and must therefore draw on its capital of living matter; but the capital being attacked and spent to maintain the life of the cell, must, of necessity, become reduced in amount, and the cell as a whole must become smaller, if we do not suppose that the waste products accumulating within the cell help to increase its bulk.

It has been suggested that all sexual organisms have probably to pass, during a certain early stage of their development, through an hermaphrodite condition, before either primary sexual characters, *i.e.*, such characters as are directly associated with the essential functions of the sexes, or secondary sexual characters, as the numerous distinctions in size, colour, skin, skeleton, &c., are developed; in other words, before male (katabolic) or female (anabolic) tendencies have arisen.

I assume now, according to the hypothesis of katabolism and anabolism, that as soon as distinct evidences of, say, male characteristics can be demonstrated in a unisexual individual, that the respective individual has acquired a katabolic habit. We have, however, seen that the term katabolism is equivalent to a reduction in the amount of the cell's capital of living matter.

Let us now take "man" as an illustration. At the fourth month of intra-uterine life the sexes are distinct, and if the fœtus be a male, then we must suppose that it has acquired already a katabolic habit, and that the older it gets, *i.e.*, as its primary and secondary sexual characters develop more and more, that katabolism will keep step with this development, nay, what is more, that it will be the cause of this special development. The natural question arises, if a four month old fœtus has acquired a katabolic habit, and if the units building up the fœtus, *i.e.*, if its cells, are katabolic, how can the fœtus develop into a strong man? Each cell, katabolic at the fourth month, and living on its capital of protoplasm, undergoes division, and the daughter-cells, more katabolic than their parents, must reduce the original capital even more. Notwithstanding this continual and ever-increasing loss of capital, the fœtus develops into the active boy and the vigorous man. Surely katabolism must stop somewhere and anabolism take its place, or how could we have an increase in bulk?

A cell whose original capital has been reduced by katabolism from 100, say to 80, divides, and if division be equal, each daughter-cell will obtain a capital equal to 40, and each daughter-cell, following in the habits of its mother, will reduce the capital even more, say to 30, and will, on division, provide either of its offsprings with only a capital of 15. Such a habit would very soon lead to an exhaustion of the capital, or, in other words, there would be no plasm left to undergo division, and the fœtus, instead of growing to maturity, would become reduced to a heap of waste products (katastates).

If, then, we cannot imagine a katabolic male embryo to develop into an adult organism without anabolism preponderating, *i.e.*, constructive metabolic changes, after each cell-division, increasing the bulk of capital received by each

daughter-cell, then it is erroneous to speak of the male animal as katabolic as long as it has not reached maturity, and therefore, also primary, and many secondary, sexual characteristics cannot be the outcome of katabolism.

To prove in a similar way that the female is not an anabolic organism is not possible, as the authors suppose a female to be living considerably below its income, but although it cannot be proved directly that the female does not owe its female characters to preponderant anabolism, still we may, I believe, justly infer that if katabolism be not the factor producing maleness, that neither will anabolism produce femaleness, as both anabolism and katabolism, femaleness and maleness are, according to the author's views, antithetic.

Is it possible that the authors, notwithstanding many sentences to the contrary, meant to convey as their conviction, that the female was *relatively* more anabolic than the male ?

Take man again as an illustration. We could suppose two fœtuses to exist in their fourth month, having exactly the same weight, and becoming simultaneously differentiated into a male fœtus, M, and a female fœtus, F. If, further, an equal amount of food-material be assimilated by both M and F, then according to the supposition of the relative anabolism of F, with each successive month and year, say up to an age of twenty years, the difference in weight and bulk between M and F ought to become more and more marked. If we resolve the anabolic F into its units, we would find that greater relative anabolism in a cell means that it will grow to a greater size than a corresponding cell of M would. Two possibilities suggest themselves to me: either such an enlarged cell must divide at a quicker rate than the relatively katabolic M-cell to keep its size within certain limits, corresponding to those of M, or if the rate of division in M and F be the same, then with each successive division the cells of F must result in two daughter-cells larger than those of the corresponding division in M.

Whatever possibility we take into account, it is obvious that, owing to the enormous number of generations of cells intervening in the period of twenty years, an originally exceedingly small difference in relative anabolism would be

sufficient to cause a great difference either in the number or the size of cells between M and F, a difference which must make itself evident by the larger size of F at the time of maturity.

We find, however, statistically, not only the male child to be bigger and heavier at birth, but also the man heavier than the woman; facts which are decidedly against the view of the female being relatively more anabolic. Another fact* might also be brought forward, that, namely, adults remain of practically the same size for the rest of their lives, thus showing that the processes of anabolism and katabolism are exactly balanced. That also in sexual cells we have constructive and destructive metabolism balancing one another, I shall endeavour to show afterwards.

The only objection that could be raised against my endeavour to show that females are not relatively more anabolic is this:—I supposed that both M and F were supplied with, and assimilated an equal amount of nourishment, and that the relative anabolism of F was due to katabolism proceeding in it at a slower rate than in M. It could be urged that F, from the very fact of being anabolic, would require less nourishment than M, that therefore less nourishment would be taken up, and that such a difference in size need not result, as I have endeavoured to show, must result if an equal amount of food be assimilated by both M and F. To this I might answer, if the smaller amount of katabolism in F leads to a lessening of the anabolism, then we might say that the metabolism in F was slower than in M. If, however, the difference between M and F consist in respectively rapid and slow metabolism, and I believe this to be the case, we could hardly stretch the term anabolic to cover female tendencies, nor the term katabolic to cover male propensities.

I cannot therefore accept the view that only one theory of sex can be the correct one, namely that as femaleness was developed due to a preponderance of either *absolute* or *relative* anabolism, while similarly maleness owed its origin to katabolism.

Ryder,† in a paper, remarkable for its style and reasoning,

* As was pointed out to me by Mr Graham Kerr.

† J. A. Ryder, The Origin of Sex through Cumulative Integration, &c., Proc. Am. Phil. Soc. xxviii., 1890, p. 109.

endeavours to show that "Cumulative Integration," or assimilation beyond the current needs of the organism, is responsible for the evolution of asexual, sexual, and parthenogenetic modes of reproduction. An earlier paper by the same author,* I have not been able to procure, and assume that the second paper contains a fuller and more matured account of the ideas evolved in the previous paper, and I give therefore a short *resumé* of the paper on Cumulative Integration.

Ryder considers the flagellate forms of Schizomycetes the most ancient form of all free mobile organisms, and wanting in a differentiation into nuclear and cytoplasmic matter (p. 118), and believes that the male element (spermatozoon) represents, morphologically, a perpetuation of the most primitive form of organised existence (p. 117), and that therefore maleness, or the condition of the flagellate spore, is the primitive one (p. 143). As further, Schizomycetes possess no cytoplasm, but only chromatin, the author speaks of chromatin as the essentially male plasma (p. 123), which requires a longer time for its elaboration than the cytoplasm; and in support of the view that chromatin is the highest and latest product of cellular metabolism, the following proofs are mentioned:—It is primitively the most central element of the cell; it is most homogeneous and least like an emulsion; it is the latest to appear when developed in great quantity from the nuclei of egg-like spermatogonia.

Chromatin is further stated to control the process of intussusception of new material, a process which falls on the shoulders of the cytoplasm, and the cytoplasm in its turn to become gradually changed into chromatin (p. 121), or, in other words, the cytoplasm to be the real agent in the production of the nucleoplasm or chromatin (p. 145). If I understand the author correctly, he believes that in the most primitive forms of life, nourishment being scarce, the cytoplasm was only formed in such quantities as to be converted at once into chromatin, and that for this reason in any individual no differentiation into nucleoplasm and cytoplasm took place. After, in this way, a certain amount of chromatin had been formed, the latter broke up into smaller pieces, by direct division, and each of these smaller pieces increased in size, till from some physiological reason it split up again into

* The Origin and Meaning of Sex, Am. Naturalist, June 1889, pp. 501–508.

small fragments. Gradually, however, nourishment becoming more plentiful, the rate at which cytoplasm was formed became greater than the rate by which it was transformed into chromatin, and this resulted of necessity in an accumulation of cytoplasm round the nucleus, or as the author puts it, in the production of a "cytoplasmic field." This cytoplasmic field allowed the nucleus a larger area to exhibit its activity, and as a result karyokinesis was ultimately developed, as the most elaborated form of nuclear division.

Simultaneously with the production of a cytoplasmic field, the habit of cells to adhere to one another after division arose, and thus unicellular organisms became multicellular. Also synchronously with the development of a cytoplasmic field, sex originated. For individuals differentiated into nucleoplasm and cytoplasm attained a large size, and spermatogonia [zoosporangia, G. M.] were developed, whose function it was to give rise to a number of primitive flagellated individuals or spermatozoa [zoospores, G. M.]. Thus far reproduction is still asexual; but gradually some of these spermatogonia in their turn assimilated food material to such a degree and developed cytoplasm in such quantity, that their nuclei (*i.e.*, the chromatin) were incapable of governing the cytoplasm. The spermatogonia, cast off the parent, were then either unable to develop chromatin in a sufficient quantity to allow the latter to govern the cytoplasm, and to divide it into spermatozoa, when an ovum resulted, which, for its future development, depended on an active and more primitive spermatozoon bringing in new chromatin, or ;—a parthenogenetic ovum resulted which was able to undergo further development without the aid of fertilisation.

It is therefore evident that, according to Ryder's view, the "ovum" is nothing but a spermatogonium, *i.e.*, a cell which ought to give rise to a number of asexual flagellated primitive individuals, but which has lost this power due to an excessive assimilation of food-material. That such an ovum still attempts to give rise to spermatozoa seems to the author an established fact, for he considers the formation of polar bodies as an endeavour of the ovum to break up into spermatozoa, and therefore the polar bodies as spermatozoa. "Sexuality was then the outcome of the unequal growth of germ cells of the same species, induced by the self-regulative

influences exerted by internal physiological conditions operating under the influence of varying external conditions. The determination of the sex of an embryo has depended in some way upon a tendency early established, through some internal equilibration of the forces of growth in response to outer conditions of nutrition, &c." (p. 120). A male cell is defined as a cell with a tendency towards a preponderance of chromatin, and a female cell as one with a tendency towards a preponderance of cytoplasm (p. 121), and "the female individual may therefore be regarded in the light of a male organism, in which the excessive tendency to sporulation has been repressed or retarded" (p. 148).

We may ask, justly, why should Schizomycetes be considered the most primitive organisms, simply because of their small size and flagella? The Schizomycetes are considered, and, I believe justly, to be degraded forms of Algæ, or of Fungi; and how as regards the flagella, which certainly do not consist of chromatin material identical to that found in the body of the respective individuals? Yet the author says, "that the growth of the lowest forms of living beings is effected in the main, or ends, principally in the production of a single kind of living matter" (p. 153). To call the chromatin "the most primitive plasma," and "the male plasma," is also erroneous, for the author states himself (p. 145), that "there is the best evidence that the cytoplasm is the real agent in the production of the nucleoplasm; the latter grows, as we know, at the expense of the former." In this sentence, as in many others (p. 143), the term nucleoplasm has been used as synonymous with the term chromatin. Chromatin can, however, not be both the most primitive substance and be developed at the same time out of cytoplasm, and for this reason it is wrong to speak of male chromatin as being the primary, and female cytoplasm the secondary, constituent of a cell. To be consequent, the author should have stated that the female element, or cytoplasm, was the older, and the male element, or chromatin, the younger plasm.

I myself hold that assimilation is the only factor in determining sex, as Claude Bernard stated long ago, but do not believe it consistent with fact that female cells are nothing but retarded male cells, or cells which would have broken

up into spermatozoa if they had not been overfed. Starting with a non-sexual cell, or individuum, I believe it to have the power of developing either male or female tendencies, according to the facilities in acquiring and assimilating food.

There is still another point in which I cannot agree with Ryder, namely, that the chromatin of the nucleus is the most highly developed constituent to the cell; the researches during the last few years all tend to show that the achromatin is the really essential part of the cell, and I have to repeat what I stated above, that in all probability those constituents of the chromatin segments of the nucleus which we are in the habit of staining with the anilin dyes are only simple albuminoid compounds on the road towards a transformation into the achromatic elements of the cell, in other words, that we are in reality not staining a constituent part of the living cell, but only food particles contained in the achromatic meshwork of the nuclear and nucleolar organs of assimilation.

Hartog * defines a zygote as a cell resulting from the fusion of gametes, and a gamete as a cell which fuses with another, cytoplast with cytoplast, and nucleus with nucleus. Gametes are believed to have arisen thus, p. 79:—"Two distinct modes of fission occur in relation to the growth of the organism in Protozoa and Protophytes; in the first, after each division the daughter-cells grow to the size of the parent (more or less) before dividing in turn; in the second, the intervals of growth are suppressed, and a series of successive fissions takes place, resulting in a brood of small individuals (swarmers, zoospores, &c.). We call this second type of fission 'brood-formation,' the resulting individuals 'brood-cells.' Necessary, like facultative, gametes are essentially, in origin at least, modified brood-cells. Hence, when the ancestral development is not lost, gametes will always be produced by brood-formation, while tissue-cells (except in the earlier embryonic state) are formed by the first mode of fission."

Given this origin of gametes, the author seeks to explain the origin of binary sex, or, in other words, of maleness and femaleness, by the phenomena of gamete-formation, as seen

* M. Hartog, Some Probl. of Reprod. &c., Quart. Journ. Micr. Soc., vol. xxxiii., part 1, Dec. 1891.

in *Ulothrix*, or in *Pandorina*. In *Ulothrix* the gametogonia give rise to gametes, which vary in their number inversely to their size, while in *Pandorina* each gametogonium gives rise to eight gametes, large, medium, or small, as the case may be. Supposing, now, that gametogenic divisions in a species were inconstant, "broods of gametes would be formed, whose size was inversely proportional to the number of the brood, the extreme forms would be small, active gametes, and large, sluggish ones respectively. As the latter are ill-fitted to conjugate among one another in the struggle for pairing [*why!?*], the small, numerous active ones would be most likely to find pair with these large ones, and the rejuvenescence of such unions would be the more efficaceous, because of the difference of temperament between the parent gametes. The middle forms being produced in smaller numbers than the little gametes, and less useful either way, would tend to disappear. The difference in size between the micro- and mega-gametes would tend to increase, and a division of labour take place, the megagamete tending to accumulate nourishment, to give its zygote a good start, the microgamete gaining activity and delicate sensibility, and by this differentiation of temperament, the zygote would be the gainer. This I take to be the Origin of Sex." . . . . . "I accept, then, one main thesis of the Evolution of Sex (Geddes and Thomson), that male and female are distinguished by their respective temperaments."

If in this way binary sex, with its advantages, has been developed, what then led to "Sex" being developed at all?

Hartog quotes Haberland's, Grüber's, and Eimer's observations on nuclei, and comes to the following conclusion:— "We have ample direct evidence for regarding the apparently 'resting' nucleus in a cell as having the same sort of relation to the cytoplast as a nerve-centre has to an organism, a view supported, too, by the fact that the nucleus approximates in chemical composition to nerve-substance, being richer in lecithin and phosphorus generally than the cytoplasm. Now, in ordinary cell-division, on the principle of continuity, there is no essential change in brood-cytoplast and brood-nucleus, and the result of repeated cell-fission is merely a multiplication of these. But we know that a nerve-centre ceases to respond readily to a continued or

repeated stimulus of the same kind. It would seem, then, probable that, after a prolonged association in life continued through a series of fissions, the nucleus would respond less readily to the stimuli received from the cytoplast; consequently its directive powers would be diminished; and, conversely, the protoplasm would do its work more imperfectly; the nucleus again would be less nourished, and a vicious circle of deterioration would set up in the cell, ending in senescence and death. To prevent "degeneration and loss of constitutional vigour produced by the over-prolonged association of nucleus and cytoplast, unchanged through a long chain of fissions, the escape lies through a rejuvenescence of the 'firm,' as we may term them."

This rejuvenescence may be brought about by—

1. Rest, as in the agamous Monadineæ.
2. Change of the mode of life by Polymorphism or by Heterœcism (as pointed out by Marshall Ward, "On the Sexuality of the Fungi," Quart. Journ. Micr. Sc., 1884).
3. Nuclear migration, *i.e.*, the transference of a nucleus to a portion of cytoplasm with which it has not been associated (in apocytial plants), as through the clamp-connections and anastomoses of the Fungi with septate hyphæ.
4. Plasmodium formation, that is the cytoplastic union of cells without nuclear fusion.
5. Karyogamy, or the fusion of two or more nuclei, as well as of their cytoplasts into a uninucleate cell, the zygote. In binary union, the cytoplast of one of the gametes may be practically nil.
6 Fusion of apocytial gametoids. (Probably only a subdivision of plasmodial formation or karyogamy).

We see thus that karyogamy, *i.e.*, a union of gametes involving fusion of their nuclei, is equivalent to "the formation of a nucleus new to the cytoplast with which it is associated, a change in the constitution of the 'firm' and 'staff,' to speak metaphorically," which results in a rejuvenesced or constitutionally invigorated zygote.

Hartog's paper is undoubtedly a great boon to all who study the problems of reproduction, for a clearer and more

concise account of the phenomena of reproduction, as far as these are known to occur up to the present time, in both vegetable and animal life, could not have been written. Yet I must differ in some points, as the observations I have been fortunate enough to make in my study of the embryo-sac, point to a solution of the problems of sex in a different direction.

We must be very guarded in attributing special functions to the different organs of a cell, and although the "nucleus" of a cell seems to have "the same sort of relation to the cytoplast as a nerve-centre has to an organism," we are not as yet able to say which part of the nucleus has such a function. Is it the endonucleolus with its radiating fibres, the nucleolus, the nuclear-chromatin or achromatin, &c.?

That cytoplast and nucleus react upon one another mutually I admit, but cannot agree to the view that this reaction ceases, due to prolonged stimulation of the nucleus by its own cytoplast. The author points out himself that continuous vegetative reproduction is interfered with in *sexually* differentiated organisms; but as in primarily non-sexual organisms, and in those which have returned from a sexual to a non-sexual condition (as, *e.g.*, often occurs in the Banana), we have unlimited vegetative growth, I believe all the author could imply would be that in sexually differentiated organisms the nucleus had become specially sensitive to reactions of its own cytoplasm, and that for this reason it was soon tired out. Then sex would be equivalent to the development of a higher degree of sensibility on part of the nucleus; a sensibility which was readily blunted by the same kind of stimuli arising in its own protoplasm, and which was restored in the zygote by the nucleus coming in contact with new cytoplasm, producing different kinds of stimuli from those it has been accustomed to in its own cell.

The author has also omitted to point out why the gametogonium of *Ulothrix* gives rise to either many microgametes or to comparatively few megagametes, and how in *Pandorina*, in which the number of gametes is always eight, an impulse is given to the development of either large or small gametes.

To assume, further, that the megagamete prepares itself for the reception of the microgamete by storing up nourishment "to give its zygote a good start," and that the micro-

gamete developes "activity and delicate sensibility" to be able to hunt up the megagamete, is a purely teleological view of matters, and must be abandoned. Microgametes and megagametes are developed, due to certain physiological causes inherent to the parent, and that they are capable by their union to give rise to a vigorous zygote, is only a secondary accident, which is of the highest importance for the maintenance of the species, but, in multicellular organisms, of no interest to the parent organism, and not only of no interest to the individual, but directly injurious.

Weismann's view as to "sex" may be shortly summed up thus:—Nothing, if not teleological in his view, he considers the simplest form of sexual reproduction to have arisen from conjugation, and the latter to have been brought about by a desire to strengthen the organism in relation to reproduction, whenever, from some external cause, such as want of oxygen, warmth, or food, the growth of the individual to the extent necessary for reproduction could not take place.

After conjugation had once been established, the process soon acquired a new significance, for the mixing and blending of various hereditary tendencies which it necessarily implied, conferred upon forms possessing it a higher degree of hereditary variability, or, in other words, the power of adapting themselves to surrounding and varying conditions. This power of adaptation to changes in environment is obviously of so profound importance to the survival of the various organisms, as to account for the all-pervading existence of sexual reproduction.

A fundamental difference between male and female, or between the nuclei of the reproductive elements, Weismann does not believe in, and to prove their physiological identity, he refers to Boveri's experiments, in which echinoderm ova were enucleated, and spermatozoa introduced in their place, whereupon the ova in several cases underwent normal segmentation, and even produced a larva. He also refers to the case of *Ectocarpus*, where in certain cases the normally male element may germinate and give rise to a new plant.

R. Hertwig,* in his book, p. 52, considers the chromatin of nucleus as that part of the cell which determines the character of a cell, which influences all activities of the

* Lehrbuch d. Zool., Jena, 1891.

(cyto) plasm, and which is the real carrier of the hereditary-substance.

After this short account of the more recent theories as to the origin of sex, we must proceed to a study of the significance of the various phenomena observed during the act of fertilisation, and see how these phenomena have been interpreted by the various investigators.

Martin Barry (1843) seems to have been the first who observed spermatozoids in the ovum of the rabbit. Leuckart made the same observation in the frog (1849), Nelson in *Ascaris mystex* (1852), and Keber observed the actual entrance of the spermatozoon into the egg of the common mussel. How the spermatozoon affected the egg was not known till, in 1872, Bütschli observed two nuclei in the fecundated egg of *Rhabditis dolichura*, and till, in 1874, Auerbach, quite independently, made the same observation in two other worms, *Ascaris migrovenose* and *Strongylus auricularis.* To O. Hertwig (1875), however, belongs the credit of having demonstrated that the second nucleus is the head of the spermatozoon. Hertwig, however, at first supposed that the other nucleus was the germinal spot of Wagner, set free by the destruction of the germinal vesicle, an error which was corrected by Van Beneden, and the other nucleus was soon shown to be, as Bütschli had previously conjectured, the germinal vesicle. Van Beneden further described (1875) the fusion of the two nuclei, and compared this fusion to the conjugation of the Protonozoa and Protophyta, and in 1883 advanced our knowledge on this subject greatly by his magnificent monograph on the fecundation of *Ascaris megalocephala.* Fol (1877), however, not only observed the entrance of the spermatozoid into the eggs of *Asterias glacialis*, *Echinus*, &c., but also figured the phenomena that ensued, phenomena confirmed by many naturalists.* I cannot do better than describe these phenomena in Hertwig's words :—" The egg sends out a projection to meet the spermatozoon, and then takes it up into the interior of the yolk.

" In the protoplasm of the egg the achromatic end of the

* For this short historical account I am indebted to Prof. M'Kendrick, who, in his text-book of Physiology, pp. 223, 224, has given above account, which, apart from the condensation, has been copied almost literally.

sperm-nucleus causes an intense radiation, analogous to that observed during division. In advance of the radiation, the sperm-nucleus travels towards the egg-nucleus, it reaches the latter, unites with it, and forms, conjointly with the egg-nucleus, a single nucleus, the division-nucleus (Furchungs-kern), which latter soon develops into a nuclear spindle, the division-spindle (Furchungs-spindel), and thus gives an impulse to the commencement of embryonic development, namely, to the division of the egg. As only now fecundation has been completed, we arrive at the fundamental proposition, that the essence of fecundation consists in the union of egg-nucleus and sperm-nucleus (Echinoderm). In many instances an abbreviation of the process may occur, inasmuch as the stage of the division-nucleus (Furchungs-kern) is omitted, when the egg-nucleus and sperm-nucleus, without previous union, proceed at once to the stage of the nuclear-spindle (Furchungs-spindel), as in *Ascaris*," a fact which had been worked out by v. Beneden and Boveri.

Strasburger also considers fecundation to depend on a union of the sperm-nucleus with the egg-nucleus, and the cell-substance (cytoplasm), not to share in the process.

Guignard,* from a study of the process of fertilisation in *Lilium Martagon* and *Fritillaria*, concludes that fertilisation does not consist only in the fusion of the two nuclei of different sexual origin, but also in the fusion of the cytoplasma of the two sexual cells, as he observed the coalescence of the paranuclei (" directing spheres, or tinoleucites "). The process is shortly this:—After the division of the reproductive cell of the pollen-grain into two daughter-cells, the anterior one of the two is provided with two tinoleucites in front of the nucleus, while the egg has its two tinoleucites above the nucleus. Thus the two pairs of tinoleucites are brought in close contact with one another, they fuse, and only two tinoleucites are now seen in the egg. The newly formed pair of tinoleucites then separates, in order to allow the nuclei to fuse. Later on the tinoleucites form the poles of the zygote-nucleus, the latter divides, and induces a division of the zygote. Thus fertilisation is completed.

Sachs (Physiology of Plants, p. 768) defines fertilisation as the act by which " something " is added to the substance

* Compte Rend., C. xii. (1891), pp. 1320–2.

of the oosphere (or gamete), which was hitherto wanting to it, and which it needs for further development, and suggests that this "something" may be a ferment.

Weismann does not believe that there is any fundamental distinction between the two sexes, or between the nuclei of the reproductive elements which represent them in their most condensed form, as has already been pointed out. He further maintains that the normal egg in the higher animals gets rid of its oxogenetic plasma by the formation of the first polar body, and then removes one-half of its germplasma (and with this one-half of its hereditary tendencies) by the formation of the second polar body. This removal of the female germplasma necessitates the acquirement of some new germplasma, which latter is brought to the egg by the spermatozoon.

Fertilisation then consists in the acquirement of a certain amount of germplasma (and with it of a certain number of new hereditary tendencies), which doubles the amount of the germplasma in the egg, and thus leads to a segmentation of the ovum. Hence the segmentation of the egg depends simply on mere quantity of germplasma.

As Weismann's views are purely teleological and inspired by a desire to explain heredity, it is only natural that the author should have arrived at the very ingenious, but decidedly wrong, notion about the "functions" of the polar bodies, and that he should have considered his germplasma to be so isolated a substance in the body, uninfluenced by any environmental conditions that may act on the soma of the parent.

Strasburger maintains that sexual cells contain proportionally a smaller amount of nucleo-idioplasm than the asexual cells, and that for this reason they are not capable of undergoing further division. Therefore, between asexual and sexual cells, no qualitative, but only a quantitative, difference exists, due to the varying amount of nucleo-idioplasm. Fertilisation, according to this view, is equivalent to an increase of the mass of nucleo-idioplasm in the ovum, an increase which leads to the division of the egg.

Strasburger and Weismann then agree to fertilisation being brought about by a doubling of the chromatin-elements of the female gamete-nucleus.

Ralph believes conjugation to occur whenever nutrition is diminished, and holds therefore conjugation to be merely a special form of nutrition, and the less nutritive, smaller, hungrier, and more mobile organism, or male cell, to seek out the large, well-nourished female. Conjugation is said to be equivalent to "isophagy," the latter taking the place of "heterophagy."

Cienkowski also regards conjugation as a process of rapid assimilation.

Simon says two similar cells unite, "in order to reach the limit of their individuality," and that the union brings about a chemico-physical process, which makes the female cell capable of independent nutrition and growth, and evokes potential properties into actual life (Geddes and Thomson, p. 161).

Geddes and Thomson, p. 162, state—"In regard to the origin of fertilisation, that the almost mechanical flowing together of exhausted cells is connected by the stages of multiple conjugation with the ordinary form of the latter, while the respective differentiation of the two elements effects the transition to fertilisation proper. Historically, then, fertilisation is comparable to mutual digestion, and, though bound up with reproduction, has arisen from a nutritive want. With the differentiation of the elements on anabolic and katabolic lines, the nature of the fertilising act becomes more definite. The essentially katabolic male cell getting rid of all accessory nutritive material contained in the sperm-cap and the like, brings to the ovum a supply of characteristic waste products or katastates, which stimulate the latter to division. The profound chemical differences, surmised by some, are intelligible as the outcome of the predominant anabolism and katabolism in the two elements. The union of the two sets of products restores the normal balance and rhythm of cellular life. Ralph's suggestion is thus included and defined."

Granted that, historically, fertilisation was really comparable to [partial, G. M.] mutual digestion of two exhausted cells flowing almost mechanically together, I might understand how a new cell arises more vigorous than either parent, the [essential, G. M.] constituents of the two cells being able to feed on one another's albuminoid materials, but I cannot

imagine an egg feeding on a mass of waste products or katastates, nor am I able to see how such katastates could be the carriers of the tendencies of the male parent. Surely only half-assimilated material, or partly, or entirely dissimilated material, will never together form a new protoplasm, the bearer of the characteristics of both male and female parent. Why further, should a katabolic male cell "get rid of all accessory nutritive material"?—For the sake of a change of diet?

Although I cannot agree with the authors in their views as to the origin of sex and the interpretation to be given to the phenomena of fertilisation, yet their "Evolution of Sex" led me to my inquiry, and seems also to have led Ryder and Hartog into an investigation of this highly fascinating subject. Should my paper bring us a step nearer the solution of this difficult problem I shall rest contented.

Ryder, as we have already seen, considers sex to have arisen as the result of "Cumulative integration," the zoosporangia (spermatogonia) "either increasing enormously in size to become ova, or running down, as a result of rapid karyokinesis, into minute male elements, which are rapidly dehisced and set free." The most evident part of the egg being the cytoplasm, and of the spermatozoon being the nucleoplasm, the author concludes, p. 134, "that the origin of sex at any rate hinges upon the decision of how the disproportion between the chromatin and cytoplasm arose in the sexual products of the two sexes," and that a restoration of this disproportion between two cells has led to fertilisation.

"The male and female elements become reciprocally attractive to one another (sometimes through the production of certain chemical substances in the vicinity [Pfeffer.]), and in that their idioplasm is less different from one another than that of other cells, there is no bar to their fusion, which is also favoured by the fact that in the male cell, with its preponderant chromatin, there is now an attraction or need developed for more cytoplasm similar to its own diminished quantity, while conversely there is a similar need or attraction developed in the egg for additional chromatin, in consequence of its preponderating cytoplasm. This leads to the highest form of cumulative integration through direct

fusion of the male or female elements, or what I shall call reciprocal integration without loss of molecular identity, or as it is commonly called, to 'fertilisation.' Fertilisation is a reciprocal restoration of the equilibrium between the chromatin or nucleoplasm and the cytoplasm of both ovum and spermatozoon; this takes place not with accompanying molecular disintegration, but by actual fusion of both elements without the sacrifice of the molecular identity of either.

"Mutual digestion is not possible, for both elements are already composed of similar molecules. This molecular similarity constitutes the means through which the hereditary traits and tendencies of the male and female are transmitted" (p. 155). "The one sex appears to supply the field for segmentational activity [the ovum], the other the segmentational impulse itself" [the spermatozoon] (p. 140).

Hartog seems to hold that the essential factor in fertilisation is the transplantation of a new nucleus into the ovum, to avert the dangers of over-stimulation of either sexual nucleus by its own cytoplasm. That this hypothesis is not likely I have already mentioned above.

My conception as to the Origin of Sex is based upon views to which I have been led by the study of cell-structure.

It will have become apparent that I consider the plasm of a cell to be achromatic; that further, the stainability of a cell by ordinary anilin dyes, carmine, hæmatoxylin, &c., is merely due to food-materials in various degrees of transition into achromatic substance. The chromatin-segments of the nucleus would then be organs consisting of an achromatic network, in the interstices of which food-materials in a process of transformation are being stored (fig. 48, *chr.*).

The nucleolus would either be an organ for the further transformation of substances already elaborated by the nucleus, or simply a storehouse for food-material, which has been already transformed by the nucleus into substances directly available for the nourishment of the achromatic elements of the cell.

I have been also led to the conclusion that the achromatic frameworks of the various organs of a cell will vary from one another, inasmuch as they have undergone specialisation according to the functions which they have to perform.

Let us suppose that a primitive cell consisted of an aggregation of similar plasmic molecules, *i.e.*, there being no specialisation of any one molecule or groups of molecules; then it is highly probable that in such an aggregate of identical molecules, should they become interdependent, special molecules or group of molecules would become modified in certain special directions, according, as owing to relative position, they are differently affected by environmental conditions, such as food-supply, light, heat, &c.

If now the various functions of each of the original unmodified molecules be represented by, say, A, B, C, D, E, then specialisation in one organ might be represented by a, b, C, d, e, and that in another organ by a, b, c, d, E, and so on.

Further, if we suppose that a group of molecules least exposed to environmental conditions (*i.e.*, a group probably of central position) does not undergo functional specialisation, but simply benefits by the specialisation of the other groups of molecules, then such a centre, owing to its non-specialisation and entire dependence on its neighbours, will of necessity be influenced by all the changes which take place in the cell, changes which will be either directly beneficial or injurious to its welfare. It is this necessity which has led the non-specialised portion to become a trophic centre.

In a normal unicellular organism the demand for, and the supply of, food will tend to balance one another, the amount of food taken up depending directly on the hunger of the trophic centre and the other plasms of the cell, hunger being an unsatisfied affinity of one element or a group of elements for another element or group of elements.

When this desire for food is being satisfied, then new molecules, in some way, arise in the cell identical with those already existing. This increase in the number of molecules must lead to an increase in the bulk of the cell; but as soon as a certain size has been reached, then factors unfavourable for a ready assimilation of food, will make their appearance, as Leuckart–Spencer have pointed out, for whereas the surface increases in only two dimensions, the cell increases in three. The first plasma to be affected will be that furthest removed from the food supply, *i.e.*, the trophic centre, which, finding it impossible to get the necessary nourishment, will start the

division of the cell. Division of a cell means, however, a restoration to its pristine condition.

Such would be the life-history of an asexual unicellular organism, which has been developed along such lines as to enable it to procure not only a definite kind, but also a certain amount of that special nourishment. If, however, any increase or decrease in the amount of nourishment to which the cell has been accustomed occur, then the nutrition of the trophic centre within the cell will be altered in one of two directions:—

A. EXCESS OF FOOD.—When this obtains, the organs of the cell are able to manufacture food for the trophic centre in such quantities that the latter, always finding sufficient material for its wants, loses the habit of urging the organs to increased activity. This diminution of trophic influence will allow the cell to become larger than normal, and may even end in loss of power of division.

B. DEFICIENCY OF FOOD.—This condition results in one of two conditions, either, firstly, in death by starvation, or, secondly, in diminution of food elaborated by the organs; hunger of the centre, and increased stimulation of the organs, the latter leading to movement in search of food, *i.e.*, the cell as a whole becomes active. But this activity necessitates greater expenditure, hence still greater food-supply. The cell will be directed by its centre to go where it can obtain the greatest amount of food with the least possible expenditure, *i.e.*, it will tend to go towards a cell of its own species, which is over-fed, and which can therefore supply it with an abundance of exactly such food as, under more favourable conditions, it itself would have elaborated.

Although in the way just described a varying amount of available food may lead either to a loss of influence of the trophic centre over its organs, or, on the other hand, to a display of excessive energy, we must ask ourselves are there yet other causes which could produce the same effect? I believe there are; for quite apart from the food-supply, two cells resulting from one division need not be constituted alike. One cell may be abnormally strong on the trophic side, but weak in its organs, or *vice versa;* or a cell's trophic centre may be normal, but the organs not able to maintain the wants of the centre; or the organs may be able to perform

their physiological function, and yet the trophic centre be deficient in amount or quality to govern the organs. Let us suppose that two unicellular organisms have the same opportunity of acquiring food, but that they differ from one another in this respect, that in the cell T the balance between the trophic centre and its organs is in favour of the trophic centre, while in the cell O the reverse is the case. Then the organism T will not be able to assimilate food in sufficient quantity to satisfy its centre, while reversely in the organism O, more nourishment will be at the disposal of the trophic centre than it requires, and, by the same reasoning as above, when the amount of available food was supposed to vary I conclude again that in the organism T we will have great activity developed, while O will be characterised by its passivity.

Whatever cause may produce this loss of balance between the trophic centre and its organs, it is evident that a union of two cells, one deficient in the activity, and the other characterised by an excessive activity of its centre, would tend to restore the normal balance between the centre and its organs. It is this restoration of the balance which I believe to be the essential element in fertilisation.

Conjugation of two cells is then equivalent to the new-formation of one cell thus constituted that the trophic centre is capable of exerting its influence over the various organs, and that the organs are able to maintain their trophic centre by satisfying its chemical affinities. How this loss of equilibrium between the trophic centre and its organs is restored in the zygote is a question which I believe my observations have began to throw light upon.

I do not believe the active male cell to effect the restoration of the equilibrium, as manifested by the division of the passive female cell, by acting either as a ferment (v. Sachs), or by simply doubling the amount of chromatin in the female cell (Strasburger, Weismann, Ryder), or by being the carrier of katastates (Geddes and Thomson), or by restoring the susceptibility of the female nucleus to stimuli from its own cytoplasm (Hartog); nor have we digestion of the two cells, or isophagy as Ralph believed; but, as I have endeavoured to show, feeding of the starving cell on the surplus nourishment of the over-fed cell, with no

digestion of the living achromatic plasm, whether this be in a non-specialised condition as endonucleolar or archoplasmic matter, or in the specialised condition forming the frameworks of the nuclear and other organs.

The union of the trophic centres (archoplasmic and endonucleolar) of the two conjugating cells by "their mutual molecular attraction" (Ryder), will result, as soon as the activities of the female centre have been roused, by the want of nourishment ;—a want which will make itself felt, sooner or later, as, to all intent and purpose, the male trophic centre acts as a parasite. The corresponding organs of the conjugating cells, such as nuclear chromosomes, nucleoli and paranuclear chromatic elements, are only of secondary importance during the act of conjugation, and they may, or, what is more likely, may never fuse with one another.

We must distinguish between fertilisation and heredity, as Boveri pointed out in his famous paper on *Ascaris megalocephala*. Fertilisation will be equivalent to the restoration of trophic influence of the "female" centre over its organs, and to a satisfied hunger of the "male" centre. Heredity will be bound up mainly with the performance of those functions of the various organs which are required for the maintenance of the newly formed trophic centre: functions which will be performed as well as environmental conditions will allow ; functions which, gradually, will become modified by environment, and which, as they become modified, will provide the trophic centre with a new kind of food, and thus lead perchance to Evolution.

EXPLANATION OF FIGURES IN PLATES III*a.* and IV.

Illustrating Mr Mann's Paper on the Embryo-sac of *Myosurus minimus.*

Gynæceum: at the time when a flower expands.

Fig. 1. Young ovule: *Derm.*, dermatogen. *Peribl.*, periblem. *Pler.*, plerome. *A. S.*, physiological archesporium (*x. x.*); *x*, non-physiological archesporia.

Figs. 2 and 3, same lettering as in fig. 1. *Int.*, integument.

Fig. 4. *a:* cell undergoing oblique division.

Figs. 2 and 4 show increase in the size of the physiological archesporium.

Fig. 5. Monaster stage of archesporium, with 8 chromatin-segments.

Fig. 6. Later stage, showing inequality in the size of the two cells derived from the archesporium, *x* and *y*.

Fig. 7. The cell "*y*" of previous figure precedes its sister-cell (*x*) in division, and gives rise to the physiological embryo-sac, *E. S.*

Fig. 8. The embryo-sac, *E. S.* Apex of carpellary leaf, *C. L.*

Figs. 9[a], 9[b]. Embryo-sac with vacuoles, *E. S.*, and three non-physiological embryo-sacs, $x+x$ and *y*.

Fig. 10, *a–d.* The gelatinisation of the walls of the physiological and non-physiological embryo-sacs takes place in various degrees.

Fig. 11. Degeneration of the cell *y*. Peripheral endonucleoli and a central one in the nucleolus of the embryo-sac, *E. S.*

Fig. 12. Cells *x* and *y* degenerate.

Fig. 13[a-b]. Vacuolation of the embryo-sac, *E. S.* Its nucleolus with peripheral endonucleoli and a central one.

Fig. 14. The non-physiological archesporia have given rise to a layer of periblem, *Peribl.* The cell *y* has escaped degeneration.

Fig. 15. The embryo-sac, *E. S.*, with large ıcuole towards its micropylar end, *M. E.*, and the nucleus towards the antipodal end, *A. E.* The periblem cells and cells *x* and *y* degenerating.

Fig. 16. The embryo-sac with a central vacuole, *v*, and an apical (micropylar) nucleus, *a. n.*, and a basal (antipodal) nucleus, *b. n.*

Fig. 17[a-c]. The vacuole enlarges, and the apical cell of the embryo-sac becomes cut off from the lower one by a distinct membrane, *m.*

Fig. 18. Embryo-sac consisting of a micropylar cell, *M. C.*, and an

antipodal cell, *A. C.*, which are separated from one another, by a plate, *Pl.*, showing on focussing an anterior, *a*, and a posterior, *p*, margin.

Fig. 19. Ditto; the antipodal cell, *A. C.*, shows a vacuole, *v.*

Fig. 20. The antipodal cell, *A. C.*, precedes its sister-cell, *M. C.*, in division as proved by the more advanced karyokinesis.

Fig. 21. The micropylar portion of the embryo-sac *M. C.*, with two nuclei, separated from the lower antipodal portion, *A. C.*, by a plate, *Pl.*

Fig. 22. Ditto. The membrane m^1 is formed before the membrane m^2.

Fig. 23. Ditto. Several hyaline bodies, *H. B.*, in the micropylar cell, *M. C.* The two nuclei of the antipodal cell separated by a vacuole, *v.*

Fig. 24. Young embryo-sac giving rise to the typical number of eight nuclei—two will form the synergidæ, *syn.;* two the ovum, *ov.*+apical primordial cell, *a. p.;* two the antipodes, *ant.;* two the third antipode and antipodal primordial cell, *ant.*+*p.* *V.*, The central vacuole.

Fig. 25^a. Embryo-sac with two synergidæ, *syn.*, one ovum, *ov.*, and micropylar primordial cell, *m. p. c.*, in its apical portion, *m.;* three antipodes, 3 *ant.*, and an antipodal primordial cell in its basal portion, *a.; i–i*, septum between the two basal antipodal cells and the third antipodal cell+the primordial cell. *V.*, vacuole.

Fig. 25^b. Ditto. *Peribl.*=periblem cells derived from the non-physiological archesporia, and cap, *cap*, derived from the non-physiological embryo-sacs. *deg.* c.=degenerating periblem cells. *P*, level at which wall of vacuole is without a covering of plasm. *M. N.*, nucleus of micropylar primordial cell. *a. p. c.*=antipodal primordial cell.

Figs. 26^{a-b}, 27^{a-b}. Same lettering. Showing the amœboid processes sent out by the two primordial cells, *Pl.* Fig. 27^a, *l.*, separation of antipodal cell from the nucellar cells.

Fig. 28. Later stage, with vacuolation of synergidæ and ovum, and fusion of the protoplasm of the two primordial cells.

Fig. 29^{a-c} and fig. 30 represent the gradual approach of the nucleus of the antipodal primordial cell, *A. N.*, for purposes of fusion with the micropylar nucleus, *M. N.*

Fig. 31. Mature embryo-sac with a fully formed primary endosperm nucleus, *p. e. n.*, occupying the centre of the endosperm cell, *E. C.*

Figs. 32–45. Various stages in the formation of the primary endosperm nucleus. The following lettering holds good for all figures: *M. N.*, micropylar nucleus; *A. N.*, antipodal nucleus; nuclear membrane, *n. m.;* peripheral chromatin

elements, *chr.;* dark nuclear substance, *1;* pale perinucleolar area, *2;* nucleolus, *n. ll.;* endonucleolus, *end.;* paranucleoli, *p. n.;* degenerated paranucleoli, *m ?*

Fig. 33. Two nuclei have met obliquely, but are as yet separated from one another by the nuclear membrane which forms a septum, *s.*

Fig. 34. The two perinucleolar areas have approached one another at "*f.*"

Fig. 35. The perinucleolar areas have fused, *2.* Two paranucleoli lying in close contact, probably about to fuse, *p. ?*

Fig. 36^{a-b}. The nucleolar membranes are touching, and then the two nucleoli fusing. [Lower half of fig. 36^b has simply been sketched.]

Fig. 37. A nucleolus with kidney-shaped endonucleoli.

In Figs. 37–43 the nucleolar membrane of the antipodal nucleolus is seen as an empty bag, *n. b.*

In Fig. 38, two bodies, the nature of which is questionable, are shown, *x* and *y*. *x* = perhaps a vacuole.

Fig. 39. A pale streak, *k*, running from the nucleolus towards the directing bodies, *dir. bod. ?*

Figs. 40, 41. Several questionable bodies *?* and *dr. b.*

Fig. 40^b is a nucleolus containing a series of endonucleoli arranged as the beads of a rosary.

Fig. 42^b represents a nucleolus, with a nucleolar membrane, *1;* a peripheral densely-stained portion, *2;* a corona of small endonucleoli, *3;* a larger endonucleolus, *5*, lying above, *i.e.*, outside the central endonucleolus.

Fig. 43^b. A nucleolus with a nucleolar membrane, *n. l. m.*, radiating fibrils, *r. f.* in a peripheral paler zone of the nucleolus; four comparatively large endonucleoli, *x.;* a set of proximal or coronal endonucleoli, *prox. end.*, and a fold, *fold*, around the central endonucleolus, *c. end.*

Fig. 44^b. A diagrammatic representation of the various layers of a nucleolus: *1*, a nucleolar membrane; *2*, a peripheral set of small endonucleoli; *3*, an apparently homogeneous layer; *4*, the corona of small endonucleoli surrounding the large central endonucleolus, *5*.

Figs. 45–47 illustrate the conjugation of the two nuclei in *Scilla nutans.* We see a nuclear membrane, *n. m.*, with broad, *p. α*, and narrow, *p. β*, pores; peripheral chromosomes, *chr.*^{1}, and central ones, *chr.*^{2}; nuclear hyaloplasm, *n. h.*, with tubular fibrils, *n. f.*, and solid strands, *n. f.*^{2}.

The nucleolus fig. 45, 47, exhibits a nucleolar membrane, *n. m.* and *1*; a peripheral set of endonucleoli, fig. 45, *2*, 47, *p. n.;* a ground substance, *3;* endonucleoli, *4;* and radiating fibrils, fig. 45, *5*.

Fig. 47. The ground substance of the nucleolus exhibits a radial striation; peripheral, *p. e.*, and a central, *c. e.*, endonucleoli, &c.

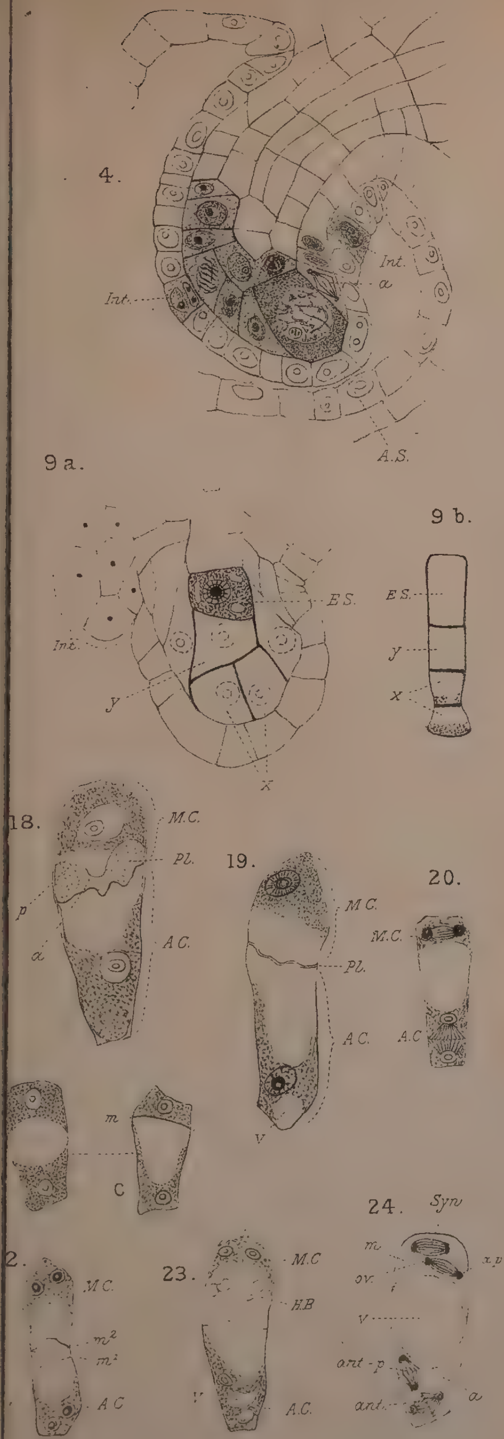
Fig. 48 is a diagrammatic representation of the achromatic elements of a normal cell. We find a cell membrane, *1;* a cell zone, *2;* a nuclear membrane, *3;* a nuclear zone, *4;* a nucleolar membrane, *5;* a nucleolar zone, *6.*

The dark lines indicate the endonucleolar network, consisting of the central endonucleolus—(*a*); the proximal or coronal set of small endonucleoli (*b*); the distal set of endonucleoli (*d*); in communication with "*a*" and "*b*" by the fibril *c;* *e*, the pores in the nucleolar membrane; *f*, the nuclear framework giving off branches to the achromatic framework of the nuclear chromosomes, *chr.;* *g*, the pores in the nuclear membrane; *h*, endonucleolar fibrils permeating the cell substance and intercommunicating at *i;* *k*, the endonucleolar fibrils establishing the continuity of the plasm between neighbouring cells.

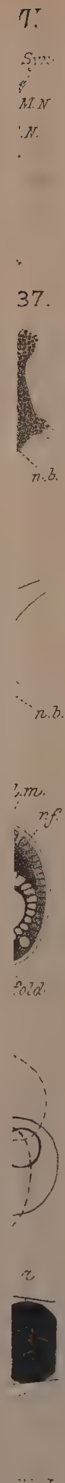
The dotted lines are meant to indicate the paranuclear achromatic substance in the centrosome, *l;* in the archoplasm, *m*, in the cell zone, *n;* in the nuclear zone, *o*, and in the nucleolar zone, *p*.

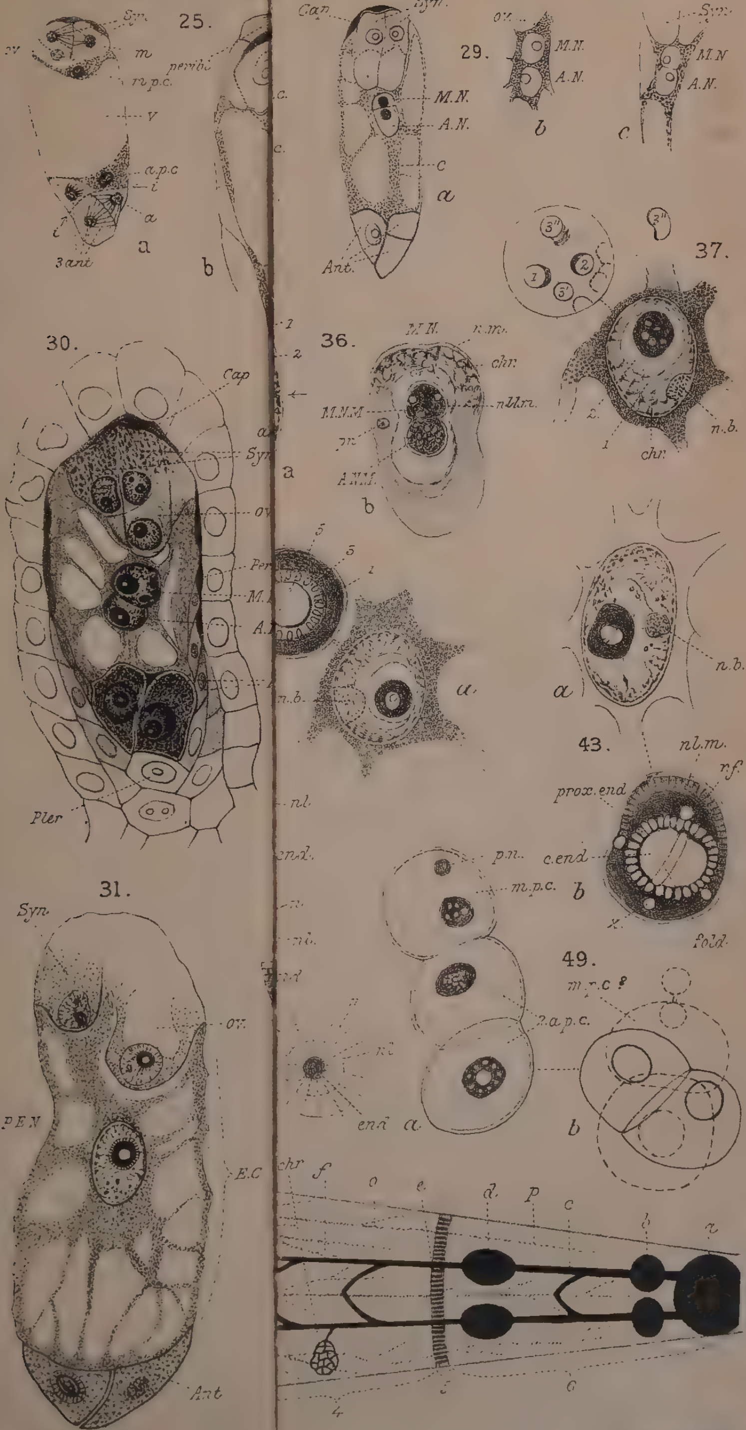
Fig. 49[a-b]. Cells as occasionally met with in the antipodal region of embryo-sac in *Scilla nutans*, suggesting that the true antipodal cells may undergo conjugation analogously to the two primordial cells forming the primary endosperm cell—*m. p. c.*, micropylar cell; *2 a. p. c.*, two antipodal cells; *p. n.*, paranucleolar body.

Fig. 50[a-g]. The mechanism of conjugation. The endonucleolar fibrils pulling the nuclei, *n*, the nucleoli, *nl.*, and ultimately the endonucleoli, *end.*, together, and then rearranging themselves round the newly-formed endonucleolus, *g*, *end.*



F. Huth, Lith^r Edin^r

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TRANSACTIONS AND PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH.

SESSION LVII.

MEETING OF THE SOCIETY,

Thursday, November 10, 1892.

Dr. David Christison, President, in the Chair.

The following Officers of the Society were elected for the Session 1892–93:—

PRESIDENT.

David Christison, M.D., F.S.A. Scot.

VICE-PRESIDENTS.

Hugh F. C. Cleghorn, M.D., LL.D., F.R.S.E., F.L.S.
George Bird.
William Craig, M.D., F.R.S.E., F.R.C.S.E.
William Sanderson.

COUNCILLORS.

Thomas A. G. Balfour, M.D., F.R.S.E.
William Murray.
William B. Boyd, of Faldonside.
Malcolm Dunn.
John H. Wilson, D.Sc., F.R.S.E.
Rev. David Paul, M.A.
Symington Grieve.
Patrick Neill Fraser, F.R.S.E.
Professor F. O. Bower, D.Sc., F.R.SS. L. & E., F.L.S.
Robert Lindsay.

Issued November 1893.

Honorary Secretary—Professor Sir DOUGLAS MACLAGAN, M.D., LL.D., P.R.S.E.
Honorary Curator—The PROFESSOR OF BOTANY.
Foreign Secretary—ANDREW P. AITKEN, M.A., D.Sc., F.R.S.E.
Treasurer—RICHARD BROWN, C.A.
Assistant Secretary—JAMES ADAM TERRAS, B.Sc.
Artist—FRANCIS M. CAIRD, M.B., C.M.
Auditor—ROBERT C. MILLAR, C.A.

LOCAL SECRETARIES.

Aberdeen—A. STEPHEN WILSON of North Kinmundy.
,, Professor J. W. H. TRAIL, M.A., M.D., F.L.S.
Beckenham, Kent—A. D. WEBSTER.
Berwick—FRANCIS M. NORMAN, R.N.
Birmingham—GEORGE A. PANTON, F.R.S.E., 73 Westfield Road.
Bridge of Allan—ALEXANDER PATERSON, M.D.
Calcutta—GEORGE KING, M.D., F.R S., Botanic Garden.
,, DAVID PRAIN, M.D., F.R.S.E., F.L.S., Botanic Garden.
Cambridge—CHARLES C. BABINGTON, M.A., F.R.S., Professor of Botany.
,, ARTHUR EVANS, M.A.
Chirnside—CHARLES STUART, M.D.
Croydon—A. BENNETT, F.L.S.
Glasgow—Professor F. O. BOWER, D.Sc., F.R.S., F.L.S.
Kelso—Rev. DAVID PAUL, M.A., Roxburgh Manse.
Kilbarchan—Rev. G. ALISON.
Leicester—JOHN ARCHIBALD, M.D., F.R.S.E.
Lincoln—GEORGE MAY LOWE, M.D., C.M.
London—WILLIAM CARRUTHERS, F.R.S., F.L.S., British Museum.
,, E. M. HOLMES, F.L.S., F.R.H.S.
Manchester—BENJAMIN CARRINGTON, M.D., Eccles.
Melbourne, Australia—Baron FERDINAND VON MUELLER, M.D., K.C.M.G., F.R.S.
Nova Scotia—Professor GEORGE LAWSON, LL.D., Dalhousie.
Ottawa, Ontario—W. R. RIDDELL, B.Sc., B.A., Prov. Normal School.
Perth—F. BUCHANAN WHITE, M.D., F.L.S.
Saharumpore, India—J. F. DUTHIE, M.D., F.L.S.
Silloth—JOHN LEITCH, M.B., C.M.
St. Andrews—Professor M'INTOSH, M.D., LL.D., F.R.SS. L. & E.
Wellington, New Zealand—Sir JAMES HECTOR, M.D., K.C.M.G., F.R.SS. L. & E.
Wolverhampton—JOHN FRASER, M.A., M.D.

Presents to the Library at the Royal Botanic Garden were announced.

The CURATOR exhibited, from the Royal Botanic Garden, specimens of the capsules of the *Papaver somniferum* pierced by tits, and branches of *Pernettyia* in fruit.

Professor BAYLEY BALFOUR exhibited specimens in spirit, from the Museum of the Royal Botanic Garden, of *Cabomba aquatica*, showing its heterophylly, and of the pitcher of *Nepenthes bicalcarata*.

The PRESIDENT (Dr. David Christison) delivered the opening address, taking for his subject "The Actual Size of the Largest Trees of Species Native or Long Naturalized in Britain, particularly in Scotland, with a Discussion of the Question of their Probable Age." The address is elaborated in the following paper:—

THE SIZE, AGE, AND RATE OF GIRTH-INCREASE ATTAINED BY TREES OF THE CHIEF SPECIES IN BRITAIN, PARTICULARLY IN SCOTLAND. By Dr. D. CHRISTISON, President.

CONTENTS OF THE PAPER.

The Presidential address on which this paper is founded was designed to show the actual size of the largest trees of species, native or long naturalized, in Britain, particularly in Scotland, and to discuss the question of their probable age. The extended form in which it is now presented gives greater completeness to the subject by the addition of information as to the size that species of more recent introduction have attained, and by a consideration of the

allied subject of the rate of girth-increase. A work of the kind is necessarily, to a large extent, one of compilation from material already published, but I have also utilized a considerable mass of unpublished matter, the result of original inquiries by my father and myself. It is also a work which may seem somewhat below the level which should be aimed at in a scientific paper, but the study of forestry in a scientific spirit being as yet only in its infancy in this country, it is mainly by a patient collection of facts that a safe foundation for it can be laid; and as notices of the dimensions and rate of growth of trees, although very numerous, are so scattered abroad as to be of little value, except to excite a momentary curiosity, it seemed to me that, by collecting together and showing in one view the most reliable data, particularly from sources which are not generally accessible, I might confer no mean service on the student of Forestry. The main sources of my information have been—(1) A series of Tree Measurements taken in the middle of last century by Mr. R. Marsham, of Stratton, Norfolk, communicated by Mr. Beevor to a volume of Letters and Papers on Agriculture, Planting, etc. Bath, 1780. (2) A Descriptive Catalogue of Important Trees, by Professor John Walker, of Edinburgh University, from measurements made in the latter part of the eighteenth century, published in a volume of Essays in 1808 after his death. These catalogues are of much value, from their antiquity, and the evident care with which they have been drawn up by men devoted to scientific pursuits. (3) Strutt's well-known Sylva Britannica, 1822–26. (4) The series of Prize Essays in the Transactions of the Highland and Agricultural Society, 1881–1892, by Mr. Robert Hutchison, with tables of measurements of a very large number of Scottish trees, chiefly taken by foresters and others under his directions. (5) Statistics of Conifers in the British Islands, collected in a careful and systematic manner by Mr. Malcolm Dunn for the Conifer Conference, and published in the Journ. Hort. Soc. 1891. (6) Information acquired, or original observations, by my father and myself. Loudoun's Arboretum and the Journals of Forestry and Arboriculture I have made little use of, as

they are more accessible to those who are likely to interest themselves in the subject.

After some introductory remarks on the mode of ascertaining the size and age of trees, I have divided the detailed part of my subject under the heads of native or long naturalized trees, and trees of comparatively recent introduction; and in place of dealing with the species in their scientific order, I have preferred to take them either according to their importance, or to the amount of reliable data which I have been able to get for them.

I have to thank a number of gentlemen, whose names appear in the course of this Paper, for their assistance. I may specially mention Mr. Robert Hutchison and Mr. Malcolm Dunn, without whose previous labours in the field my own could hardly have been undertaken. No inconsiderable part of my information about individual trees comes from foresters and gardeners on the spot, who have invariably answered my inquiries in the most careful and accurate manner.

INTRODUCTORY REMARKS.

Size of Trees.—To form a right idea of the size of a tree, we ought to ascertain its cubic contents of timber; the height to which the foliage towers aloft and spreads horizontally; the length and girth of the stem;—but the last of these characteristics is almost universally used as the best single index of size. With this limitation it might be expected that the actual size of the most remarkable trees within the small compass of our islands would be accurately known; nevertheless there are few subjects of popular and scientific interest in which our knowledge is so vague. This has arisen mainly from the most reckless carelessness in making or recording measurements, and from the want of a recognised standard of position of measurement. Multitudes of girths have been recorded without the position being mentioned, while in many others the point selected gives no true index of the size for comparison with others. Mr. R. Marsham as early as the middle of last century appears to have been the first to adopt a scientific mode of measurement. He chose 5 feet as the most convenient height for girthing a tree, and

"as being clearer of the swelling of the roots." Failing this, he took the narrowest point. He, however, took no pains to make his views known, and, in ignorance of them, Sir Robert Christison was the first to insist publicly upon the necessity of establishing a common standard of position, and, in a Paper communicated to this Society in 1878, he showed that this must be chosen where the stem is unaffected by the swelling downwards towards the buttresses and upwards towards the great branches—in fact, at the narrowest part of the stem, a point generally to be found about 5 feet from the ground, although in very old trees it may be higher, and in unusually short stems it may be lower. Of late years this principle has been very generally adopted, although from the neglect of it the vaguest statements as to the size of trees are still not unfrequently met with. In the present Paper I have adopted the girth of 5 feet from the ground, or, if necessary, at the narrowest point, as the single criterion of size, recording, however, other measurements in special cases.

AGE OF TREES. — Considering that life is annually renewed in our forest trees, there is no evident reason, apart from disease, why their vitality should come to an end; yet it would seem that, just as in the animal world, which has no such annual rejuvenation, so in the vegetable world, each species of tree has its natural limit of life. The average limits of the species, however, have not been determined, any more than the age which exceptionally favoured individuals may reach, and it is only by the gradual accumulation of facts that we can hope to form some estimate on these points. The main obstacle, however, is the difficulty in ascertaining the age of very large trees.

As to the modes of ascertaining the age of trees in general, the most reliable is when the date of planting is known, but it is surprising how seldom, in Scotland at least, this kind of evidence is to be had, even for trees of moderate age, and it is quite unavailable for aged veterans, except in a legendary and fabulous form.

Good evidence may also be obtained, but only in fallen

or felled trees, from counting the annual rings. The correspondence between these and the age may not be precise in the stems of very old trees, as they may have ceased to lay on wood below while still growing above, but the method is probably reliable enough up to a very considerable age, although rarely, if ever, available in the case of aged veterans.

At one time it seemed as if a simple and reliable mode of estimating the age of trees had been established by De Candolle, who, relying on observation of the annual rings in many tree sections, published as a well-ascertained fact that, after a period of greater activity in early youth, the annual rate of girth-increase continued throughout life at a tolerably uniform rate. But Sir Robert Christison* showed that De Candolle must have been misled by using sections taken near the ground, where the tendency to a conoidal swelling as age advances tends to equalize the rings; and that above this conoidal swelling, in the great majority of cases, there is a gradual although irregular decrease in the width of the rings with age. Hence although De Candolle's rule might answer near the base, it was inadmissible higher up. But Sir Robert also showed that even at the base it was unreliable, as the rings frequently vary much in width there within short periods of time. Hence it is not possible to ascertain the age of a tree merely by ascertaining its recent rate of girth-increase.

The age of trees even of very considerable size may sometimes be estimated, in a rough way, simply by measuring the girth, as pretty numerous data exist showing the rate of growth and the age of trees in some species at various sizes. But, in working thus by comparison, it is necessary to take the circumstances of each tree into consideration, and it is only in a few species that sufficient data for the purpose have been collected.

It is when we come to gigantic trees, however, that the most serious difficulties occur, chiefly from the almost total deficiency of data bearing on their growth during the latter part of their career. We may form some notion

* Trans. Bot. Soc. Ed., 1878, p. 225.

of the rate of girth-increase in such a tree till it attained, say, 15 feet in girth, by using the data already referred to, but we probably have none to help us for the period during which the girth increased to 20 or 30 feet. The only mode which appears to offer itself in such cases is to ascertain the recent rate of girth-increase, and to allow for a gradual diminution in the rate from that of the calculated period at, say, 15 feet, to the ascertained rate at, say, 20 or 30 feet. But it may be said that the rate varies so much in the recorded data as almost to nullify this system. I believe, however, that we are not likely to err, if we take the quickest growers for our models, as my experience in tree-measuring goes far to prove that quick growth goes along with vigour, and I also found in connection with the great frosts of 1879–80–81 that the quick-growing trees of each species suffered least.

We have still to consider the modes of ascertaining the present or recent rate of girth-increase. The most accurate and ready means is by using borers to extract cylinders of wood on which the annual rings can be counted. Mr. J. E. Bowman* was the first to adopt this simple method, but it was unaccountably neglected at the time, and it was left to the German foresters to revive or rediscover it in recent years. Mr. Bowman's borer penetrated only to a depth of a few inches, but cylinders can now be extracted to a much greater depth, and, if taken at several points at the same level, yield most valuable and reliable results. But although no harm is done to the trees by this instrument, permission to use it is not likely to be granted by the owners of interesting old trees, and the only remaining plan is the tedious one of taking girth measurements for several successive years. This plan has one advantage over boring, as it shows whether the stem is still continuing to grow, and it is eligible enough in trees of very great size which retain their health and vigour.

But in gnarled, "bumpy," and particularly in decaying stems, neither by this nor by any other means can we hope to arrive at any satisfactory result. The chief difficulties in estimating the age of such decaying veterans

* Ann. of Nat. Hist., 1837, i., N.S., p. 28.

are—(1) We probably have no means of ascertaining how long the stage of decay has lasted. That it may endure for several centuries we have sufficient reason to believe, at least in yews and oaks. (2) We do not know whether in this stage of decay annual rings may or may not be formed in the stem, either regularly or occasionally. Mr. Strutt, indeed,* quotes the statement of a Mr. South that an ancient hollow oak had increased some inches in twenty years, though "as hollow as a tub"; and hence "that hollow trees have not attained their great bulk when sound, as the shell increases when the substance is no more." But no proof of the alleged increase is given, and faith in it is not increased by the conclusion "that a tree which at 300 years of age was sound, and 5 feet in diameter, would, if left to perish gradually, in its thousandth year become a shell of 10 feet diameter." (3) To measure these ancient stems accurately, covered as they generally are with bumps and excresences, broken into, it may be, by gaps, and with scaling bark, is well nigh impossible. Moreover, any apparent growth may be only due to the bumps, and should therefore be regarded rather as a diseased than a natural increase. On the whole, I fear we must conclude that any estimate beyond the roughest guess at the age of many such veterans is scarcely possible.

A. DECIDUOUS TREES.

I. The Oak (*Quercus robur*).

Scottish Oaks.—The oak rarely attains in Scotland the size and vigorous look so commonly met with among its English brethren. The stem often enough gains considerable proportions, but the branches are rarely thrown out in the free manner ordinarily met with in English oaks, and the foliage is comparatively thin. In mature oaks left standing in Highland copses the arms are often widespread and picturesque, but the poverty of the foliage is usually quite remarkable, the leaves being in scanty small tufts, and the shade cast by the trees consequently imperfect. The test of girth measurement clearly proves

* Sylva, p. 5.

the greater growing power of the oak in England, the recorded trees in that country above 30 feet in girth at 5 feet from the ground being more numerous than those above 20 feet north of the Tweed. Nevertheless, in some favoured localities of the north, large and handsome oaks do occur. The most remarkable of them for girth or height have probably found their way into Mr. Hutchison's catalogue of 151 Scottish oaks (Trans. H. and Agr. Soc. Scot., 1881, xiii., 218), from which we have extracted those that reach or exceed 20 feet in girth, at 5 feet up, or at the probable narrowest point.

	Girth.		Height of Bole.	Height of Tree.	Spread of Branches.
	Ft.	In.	Ft.	Ft.	Ft.
*Lochwood, Dumfriesshire, .	20	0	19	...	...
Invernytie, Perthshire, .	20	10	30	76	...
Cadzow, Lanarkshire, . .	21	0	12	45	66
Do. do. . .	22	9	30	48	100
Lee, Lanarkshire, . .	†23	0	8	68	...
‡Methven, Perthshire, . .	20	1	8	...	...
100 feet or upwards in height.					
Hopetoun, West Lothian, .	8	8	93	110	...
Binning, East Lothian, .	11	6	20	103	...
Springwood Park, Roxburgh,	16	0	35	100	...

* None there above 17 feet in girth, fairly measured (D. Christison, 1890).
† At 3 feet, probably the narrowest part of a short stem.
‡ At 3 feet, the narrowest of a fine symmetrical 8 ft. stem (Col. Smythe, 1893).

Number recorded above 15 feet in girth.

20 feet in girth and upwards, ...	5
19 to 20 feet in girth, ...	3
18 to 19 ,, ,, ...	4
17 to 18 ,, ,, ...	6
16 to 17 ,, ,, ...	5
15 to 16 ,, ,, ...	32
Total 15 feet and upwards, . .	55

The Lee oak measures 28 feet 6 in. at 5 feet, but this large result must be due to the swelling towards the limbs, as at 3 feet the girth is only 23 feet. From the massiveness of the arms, however, it is probably the biggest oak in Scotland, although the Springwood Park tree, 100 feet high and 16 feet in girth, must be one of the grandest.

In 1771 Dr. Walker estimated the girth of the "Wallace Oak," Torwood, Stirling, to have been about 22 feet at 4 feet up, but apparently only half the circumference of the trunk remained; and he mentions an oak on the north side of Loch Arkeg, Lochaber, measuring 24 feet 6 in. at 4 feet up, as being "the largest oak of which we have any account in Scotland."

English Oaks. — Newland, Forest of Dean, Gloucestershire.—By common consent the oak is king of British trees, but which is the king of British oaks is not so easily decided. By the single test of greatest girth, however, the Newland oak is entitled to the honour, as it is the only one in which the stem girths nowhere less than 40 feet. In April 1893, with the aid of the Rev. Mr. Bagnall Oakeley and Dr. John Beddoe, F.R.S., I measured it at four points. Other measurements yielding much higher results have been published, but as our observations agreed, within a few inches, with the girths taken for me three years previously by Mr. and Mrs. Oakeley, the combined results here given may be accepted as substantially correct, considering the "bumpy" nature of the surface dealt with.

Girth at the ground, .	45 ft. 7 in.	Spread of foliage, N. to S.,	65 ft.
,, 3 ft. up, . .	45 ft.	,, ,, E. to W.,	57 ft.
,, 4 ft. up, . .	43 ft. 5 in.	Height of tree, ...	50 ft.
,, 5 ft. up, . .	43 ft. 6 in.	,, stem, ...	9 to 10 ft.
,, 7 ft. up, . .	43 ft.	Girth of largest limb, . .	8 ft.
,, 8 ft. up, . .	42 ft. 3 in.		

The measurements show that the tree springs from the ground without buttresses. The stem, instead of dividing into two or three great limbs, gives off eight branches of moderate size in a circle at a nearly uniform level 9 feet above ground. What may be called the roof of the stem has measured 6 feet by 4 feet 6 inches within the circle of limbs, but it has mostly rotted away, showing the stem to be a hollow shell, although without a lateral break. The peculiar form of the tree is no doubt due to pollarding, a practice so common in ancient times, to provide fodder for cattle, that an old writer complains that scarcely a fine tree in England had escaped it.* It is interesting to note

* I am informed by Mr. Oakeley that in this very dry spring, from a want of fodder, the farmers in his district had recourse to pollarding to feed their cattle.

that, apparently because buttresses were not required in a pollard, they were not produced. This tree stands conspicuously alone in a gently sloping field, and no other oak in the Forest of Dean at all approaches it in size.

COWTHORPE, WETHERBY, YORKSHIRE.—If in addition to girth other points are considered, the oak at this place may lay a strong claim to the sovereignty, a claim, indeed, which was admitted by Mr. Marsham (Op. cit. 1780), who states that "the largest oak in England is one near Wetherby," and by Hunter in his edition (1776) of Evelyn's Sylva. Referring to an oak in Sheffield Park, he says, "Neither this nor any of the oaks mentioned by Mr. Evelyn bear any proportion to one now growing at Cowthorpe. The dimensions are almost incredible." He then gives them, as shown in my table, concluding his description thus: "The foliage is extremely thin, so that the anatomy of the ancient branches may be distinctly seen in the height of summer. When compared to this, all other trees are but children of the forest."

Strutt (1822) says that Hunter's description "so nearly answers to the present state that the tree does not appear to have suffered material deprivation since." Yet his drawing, compared with Hunter's, shows an evident diminution in height and branches. A photograph of 1859, sent me by the Rev. J. J. D. Dent, Hunsingore, shows perhaps a further diminution in height, but so great a revival of the foliage that it no longer deserved the reproach of "showing the anatomy of the ancient branches"; and this improvement continued in 1887, when I saw the tree. The stem, the condition of which is not described by the earlier observers, I found to be a hollow shell, to which access is gained by a considerable gap, which, however, does not interfere with the accuracy of measurement. My notes unfortunately were lost, but Mr. Dent has kindly supplied the loss by careful measurements taken in 1889.

Measurements of Oak at Cowthorpe.

	1776. — Dr. Hunter.	Before 1780. — Mr. Marsham.	1889. — Rev. J. Dent.
Girth at the ground, . . .	78 ft.	...	54 ft. 6 in.
,, 1 ft. up, . . .	...	...	49 ft. 6 in.
,, 2 ft. up, . . .	...	...	47 ft.
,, 3 ft. up, . . .	48 ft.	...	44 ft. 10 in.
,, 4 ft. up, . . .	...	40 ft. 6 in.	42 ft.
,, 5 ft. up, . . .	...	36 ft. 6 in.	...
,, 5 ft. 4 in. up, . .	...	...	37 ft. 5 in.
,, 6 ft. up, . . .	...	32 ft. 1 in.	...
,, 6 ft. 6 in. up, . .	...	...	35 ft. 9 in.
Height of tree, ...	85 ft.	...	...
Length of longest branch, .	48 ft.	...	36 ft.

The table illustrates the difficulty of arriving at the truth as to the size of old trees. No one who has seen this tree can believe that by any process of loss its girth at the ground can have diminished between 1776 and 1889 by 24 feet, or even by 3 feet at 3 feet above ground. But Mr. Dent's measurements were taken expressly for me with every care, and I have no doubt are substantially correct. It is possible, indeed, that in measuring such an irregular surface, where the slightest shifting of the tape makes a great difference, he may have missed the narrowest point, and unless we suppose growth to have taken place in the decaying tree since Mr. Marsham's measurements, the date of which is uncertain, this must be the case. My recollection is that I got one measurement as low as 34 feet.

In further illustration of the unreliability of earlier statements, Strutt, speaking of this very tree, remarks, "In girth, indeed, it is inferior to the magnificent remains of the oak in Salcey Forest." But, on turning to his account of it, we find the dimensions, as taken in 1794, to be 46 feet 10 inches at the bottom, and 24 feet 7 inches at 3 feet up. Now Strutt accepts Hunter's 78 feet and 48 feet at the corresponding positions in the Cowthorpe oak as correct, and yet calls it inferior to the Salcey Forest tree!

Oaks above 20 feet in girth must be numerous in England. To take a single locality, in a series of measurements of oaks at or near Moccas Park, Herefordshire* (comprising forty-eight above 15 feet in girth at 5 feet up), there are no less than eleven in the park, and in other parts of the country there are eighteen more, all girthing 20 feet or upwards. These measurements were taken by "a commissioner" for the Club, and they are confirmed by an unsigned list among my father's papers, in which, although the results do not strictly agree, they are near enough to show the substantial accuracy of both. Even 30 feet is not an extremely rare girth for the English oak, as, in addition to the Cowthorpe, Newland, and three of the Moccas Park trees, I have found records of the following:—

IN HEREFORDSHIRE (Trans. Woolhope Club, 1870), all at 5 feet up—The Rosemaund Oak, 34 feet; Brampton Brian Park Oak, 30 feet; Croft Oak, 34 feet; Nonupton Oak, 33 feet (at 4½ feet), 50 feet at the ground, destroyed by fire, 1851; Cowarne Court Oak, 37 feet 8 inches, owing partly to a protuberance, rapidly narrows; Newbury Oak, 31 feet, destroyed.

OAK IN HOLT FOREST, Bentley, 34 feet at 7 feet, a large excrescence at 5 and 6 feet making measurement there unfair (R. Marsham, 1759).

FAIRTOP OAK, Epping Forest, 31 feet 9 inches at 5 feet (R. Marsham, 1754).

EARL OF THANET'S OAK, Whinfield Park, Westmoreland, 31 feet 9 inches at 5 feet (R. Marsham, 1765).

THE SELBORNE OAK, described by Gilbert White as girthing 34 feet at 7 feet, with a stem of 16 feet, containing 1000 cubic feet of timber.

THE QUEEN ELIZABETH OAK, Huntingfield, Suffolk, 34 feet at 5 feet (Strutt).

Not far short of these comes MAGOG, Yardly, 54 feet 4 inches at the roots, and 31 feet 3 inches at 3 feet up (Strutt); and a fine solitary oak in a field near Bristol which I found to girth 28 feet at 5 feet up.

* Trans. of the Woolhope Club, 1870.

1. Rate of Girth-Increase in Oaks of known Age.

(*a*) Oak at Stratton, Norfolk, planted in 1720 by Mr. Marsham.

Date.	Girth. Ft.	In.	Period. Years.	Increase. In.	Rate. In.	
1742	2	11¾	22	36	1·63 at 5 ft.	Mr. Marsham.
1778	7	9	36	57	1·58 do.	do.

"Perhaps the growth was helped by digging a large circle round it in several winters, and in other years having that circle covered with greasy pond mud." He also washed the stem frequently in dry seasons.

(*b*) Oak at same place, known from a Deed to have been planted in 1580.

Date.	Girth. Ft.	In.	Period. Years.	Increase. In.	Rate. In.	
1760	15	2¾	180	182¾	1·01 at 5 ft.	Mr. Marsham.
1778	16	3½	18	12¾	0·70 do.	do.

(*c*) English oaks measured in 1889 by Mr. Collins, Trentham, Staffordshire. Age accurately known from records on pillars of the dates of planting, and tested by counting the rings on many felled specimens.

Situation.	Number of Trees.	Age.	Girth at 5 ft.		†Av. Annual Increase.		Height.	
			Average.	Largest.	Of all.	Of Largest.	Average.	Annual average.
		Yrs.	In.	In.			Ft.	In.
*Trentham, .	111	71	49·75	74	0·76	1·13	58	8·17
Windsor, . .	30	69	50·25	62	0·80	0·98	60	8·70
Sherwood, .	10	75	49	53	0·70	0·76	65	8·66
Weston, . .	10	74	58·75	67	0·84	0·98	66	8·78
Chillington, .	10	84	57·75	93	0·74	1·19	66	7·85

* Includes all in Ashgreen Plantation.
† Deducting six years for growth up to 5 feet.

(*d*) "Many oaks at Cammo, Midlothian, planted 150 years ago, and age proved by counting rings in felled trees, vary from 9 to 10 feet in girth, giving a rate of from 0·72 to 0·80, and for the largest (11 feet girth) of 0·86. Rate of the latter confirmed by two years' measurement, showing 0·75 still."—Sir R. C., 1880.

(*e*) Age ascertained from the annual rings (Mr. Collins, Trentham).

Girth at 5 ft.		No. of Rings.	Average Annual Increase.
No. 1, ...	7 ft. 3½ in.	86	1·01 in.
No. 2, ...	11 ft. 10 in.	192	0·74 in.

(*f*) Oak at Baslow, Cheltenham, thrown down by a flood, 1879. Rings counted by Mr. E. M. Wrench, surgeon, and information furnished by him to Sir R. Christison.

Girth 3 ft. up.		No. of Rings.	Average Annual Increase.
Without the Bark.	With the Bark.		
17 ft. 8 in.	18 ft. 3 in.	479	0·46 in.

(*g*) Oak at Cammo, Midlothian. Rings counted by Sir R. Christison, at 2 feet above ground.

	Average Annual Incr.	
First 40 years, . .	1·50 in.	After this the tree almost ceased to grow for 30 years before being cut down.
Next 80 years, . .	0·82 in.	
For 120 years, . .	1·00 in.	

2. Rate from Girth Measurements in Trees of unknown Age.

(*a*) Young oaks in Edinburgh Arboretum, measured by me, 1890–92.

No.	Average Girth, 1892.	1889–1892. Average Annual Increase.		Average of Three, 1890.
		Of Three.	Of Best.	
Three	10·26 in.	0·84	1·06	0·98

(*b*) Oaks, Dalswinton, Dumfriesshire, originally marked and measured by Sir R. Christison and Mr. J. M. Leny of

Dalswinton, and latterly by Mr. W. M. Leny and myself, at various dates from 1836 to April 1893, at from 3 to 4 feet up. They have all (April 1893) been failing for some time, and are now shabby looking. I have only given their increase till failure evidently began, at various dates. Their average girth is now, at 3 to 4 feet, 12 feet 8 inches; and at 5 to 6 feet, 11 feet 7 inches.

	Term of Years.	Girth at First.	Girth at Last.	Increase.	Annual Rate.
		Ft. In.	Ft. In.	Ins.	In.
No. 1, . .	51	8 2	12 0·5	45·5	0·90
No. 2, . .	36	9 6	12 0	30	0·83
No. 3, . .	37	10 5½	13 0	30·5	0·82
Averages,	41	9 4	12 4	36	0·85

(*c*) Oak at Craigiehall, West Lothian, measured by me for ten years.

Girth, 1887, 10 ft., 7·25 in. Average increase for ten years previously, 0·68 in. at 5 ft. up.

(*d*) Oaks at Polloc, Renfrewshire, for sixty-eight years ending 1880 (Mr. Hutchison's Table).

	Girth.		Increase.	Annual Rate.
	1812.	1880.		
	Ft. In.	Ft. In.	In.	In.
No. 1, ...	6 8	10 1	41	0·60
No. 2, ...	7 6	11 6	48	0·70
No. 3, ...	7 9	11 9	48	0·70
No. 4, ...	8 9	12 4½	43½	0·64
Averages, .	7 8	11 5	45	0·66

(*e*) Oak at Methven Castle, Perthshire (Colonel Smythe).

Date.	Girth.	Increase.	No. of Years.	Annual Rate.
	Ft. In.	In.		In.
1795	14 6	...	...	...
1811	16 0	18	16	1·12
1879	19 7	43	68	0·63
1892	20 1	6	13	0·45
1795 to 1892	...	67	97	0·69

(*f*) Oak near, and north of, Bewick's Oak, West Felton, Salop (Mr. John Dovaston, in a letter to Sir R. Christison).

Girth.			Rate.	
1811.	1836.	1879.	1st Period, 15 years.	2nd Period, 44 years.
Ft. In.	Ft. In.	Ft. In.	In.	In.
2 9	4 8·5	7 7½	1·56	0·80

(*g*) Herne's oak, Windsor, 26 feet in girth when blown down. On a block, 5 inches thick, of exterior decayed wood, there were 142 rings; on the inner inch, 21½; on the outer inch, 44 (Sir R. Christison).

3. Estimation of Age in Ancient Oaks.

We may form an approximate estimate of age in oaks of very considerable size, but available data in the case of the great giants are so defective, and the difficulty of estimating the period when they may have been "standing still" in a state of decay is so great, that in them estimation is little better than guess-work. Let us make the attempt, however, on the Cowthorpe tree.

The oldest oak on my list, with a well-ascertained age, is the Baslow tree (1 *f*), which had 479 rings at a height of 3 feet, and allowing 6 years for growth to that height, must have been 485 years old. Its girth was 18 feet 3 in., and consequently its rate for the whole period was 0·46. Now the Cowthorpe oak is almost twice that girth, and if we allow its rate to have been 0·46 till it was 18 feet in girth, and take half that rate for the last 18 feet, its age, without any allowance for "standing still" in the period of decay, comes out at about 1450 years. But the Baslow tree was slow of growth, as one radius increased at only half the rate of the other, and because some of my trees yield a much higher rate up to a considerable size. Thus rates of 1·50 up to 40 years of age; of 1·13 up to 71; of 1·19 up to 84; of 1 up to 86; of 0·86 up to 150; of 0·92 for 39 years in a tree 11 feet

3 in. in girth; lastly, of 0·69 for 97 years in a tree 20 feet 1 in. in girth, are recorded.

Taking the most favourable figures, we may construct the following scheme for a tree 20 feet 1 inch in girth, like the Methven oak (2 *e*).

	Increase in Girth. In.	In.		In.		Years.
From	0 to	93	at annual rate of	1·10	gives	84
,,	93 to	135	,,	0·92	,,	46
,,	135 to	192	,,	0·76	,,	75
,,	192 to	241	,,	0·61	,,	80
	Total,	241	Average,	0·84	Total,	285

Thus we get 285 years as the *possible* age of an oak 20 feet in girth, which has grown at the greatest rate that our tolerably reliable data supply, or 0·80. The period might indeed be considerably reduced if we accepted the rate of the Methven oak, between the girth of 14 feet 6 in. and 16 feet, as correct. Frequent measurements of this tree, although at irregular intervals (of which I have given only a summary in the table), have been recorded for the past 97 years, and although there are no means of checking their accuracy, and 1·12 at the size mentioned seems an extraordinary rate, yet the form of the stem is such that a considerable shifting of the point of measurement would apparently not cause serious error, over a long period of time. Accepting the rate of 1·12, and without making any allowance for the rate having been greater previous to the tree attaining 14 feet 6 in. in girth, the age of this 20 feet oak would be about two and a half centuries, but allowing for a greater rate in its earlier life it would not be much above two centuries. But at the size of the Methven tree the Cowthorpe oak had still 15 feet 8 in. to grow, and supposing the rate during this latter period reduced to half that which brought the tree in our scheme to 20 feet, or 0·40, and adding upwards of a century, during which decay is known to have been going on, the age of the Cowthorpe tree would be 855 years. It could not well be less, except on the supposition either that such a giant does grow throughout more quickly than at the quickest rate ascertained for smaller trees, or that the rate, instead

of gradually diminishing, continues unimpaired till a very advanced age. But the age may be a great deal more if the rate after all has only been an average one, and if the period of decay has been longer than is recorded, and if during that period there has been little or no growth. That the age might well be a great deal more is shown by the very slow rate of the Herne's oak (2 *g*) towards the end of its career, ascertained to have been only about 0·20 for the last 142 years, and 0·13 for the last 44 years of growth; and this in a tree only 26 instead of 36 feet in girth. Here it may be noticed that by De Candolle's method the inner inch of the last five would make Herne's oak 1013, but the outer one 2077, years of age. All this proves, I think, the impossibility of forming even a rough estimate of the age of such a veteran as the Cowthorpe oak, without far more precise and extensive data than we at present possess. But we may go so far as to say that it is *possibly* not much more than eight centuries old.

II. THE BEECH (*Fagus sylvatica*).

The beech flourishes better in most parts of Scotland than any other deciduous tree. It seems somewhat surprising, then, that in Mr. Hutchison's list only three are to be found as much as 20 feet in girth at 5 feet from the ground, and of these but one, the short-stemmed Eccles tree, reaches 20 feet at its narrowest part. Even at the lesser girths of 19 to 20 feet he records not one, and between 16 and 19 feet, but fourteen. On the other hand, splendid beeches, between 10 and 14 feet in girth, are so numerous in Scottish avenues and plantations as to lend much probability to Mr. Hutchison's belief that the older generations of the species were rarely allowed to survive to a great age, and that a newer generation, planted most extensively about the beginning of the eighteenth century, are now coming to great perfection, but have not yet had time to yield a crop of giants.

Scottish beeches above 17 feet in girth, at 5 feet from the ground (Mr. Hutchison's Table of 232 Scottish Beeches, Trans. H. and Agr. Soc. Scot., xiii., 1881).

	Girth.		Height of Bole.	Height of Tree.	Spread of Branches.
	Ft.	In.	Ft.	Ft.	Ft.
Kinnaird, Forfar, . . .	17	3	18	75	...
Cramond House, Midlothian,	17	5	...	85	..
Yester, East Lothian, . .	17	6	19	70	...
Dunkeld, Perth, . . .	17	6	11	82	130
Drummond Castle, Perth, .	17	8	10	77	...
Dalmeny, West Lothian, .	18	0*	6	...	...
Ardkinglass, Argyll, . .	18	9½	...	92	108
Eccles, Dumfries, . . .	20	3	4†	65	100
Belton, East Lothian, . .	20	4	31	63	...
Newbattle, Midlothian, . .	21	2	17	95	130†
Highest Beeches.					
‡Methven, Perth, ...	16	3	...	120	110
Milne-Graden, Berwick, .	13	7	...	122	...

* At narrowest, Sir R. C., 1874. † Sir R. C., 1878. ‡ Col. Smythe, 1893.

Number above 15 feet in girth at 5 feet from the ground.

Between 15 and 16 feet, ...	15
,, 16 and 17 ,, ...	8
,, 17 and 18 ,, ...	5
,, 18 and 19 ,, ...	1
,, 19 and 20 ,, ...	0
20 and upwards, ...	3
Total above 15 feet, . .	32
Number recorded between 90 and 100 feet in height, .	34
,, above 100 feet in height, ...	22

The lofty beeches recorded by Mr. Hutchison are also of remarkable girth. At Arniston, Midlothian, and no doubt in many other places, beeches of considerable girth, and 100 feet high, are numerous. At Cramond Bridge, in the Craigiehall grounds, there is a grove which thirteen years ago numbered sixty, all about 100 feet high, and several above it, but girthing only between 6 and 9 feet.

Although the giant beeches are inferior in girth to the giant oaks in Scotland, yet their general superiority is shown by their greater height and the wider span of the branches.

(*a*) Newbattle Beech, Midlothian.—If we take into consideration height, spread of foliage, vigorous growth, and grandeur of aspect, as well as girth, the Newbattle

beech, besides being the king of Scottish deciduous trees, is probably one of the grandest beeches in the United Kingdom. It stands in the well-sheltered haugh of the River Esk behind Newbattle Abbey. The stem rises from the ground by several strong buttresses, but at about $4\frac{1}{2}$ feet up it already forms a cylindrical bole, which an encircling tape touches pretty nearly all round. The bole, after ascending with a beautiful but not deeply marked spiral curve, divides into a larger and smaller limb, the fork being about 17 feet above ground. At a further height of 5 or 6 feet the larger limb bifurcates, and finally subdivides into the mass of branches and twigs which rise to a height of about 100 feet. The ramification consists of two divisions, the upper forming the great head of foliage, while the lower consists of about a dozen branches, which, springing from a height of about 25 feet, arch downwards, reach the ground from 20 to 30 feet from the trunk, and form around it a natural arbour, about 60 feet in diameter. Some of these branches break up into a number of small ones, which trail along the ground for some distance, and finally turn upwards at the outer margin of the tree; but four or five others, comparatively slender, reach the ground without branching, and after rooting give origin to a number of veritable young trees much thicker than their parent limbs.

Thus I found, in autumn 1892, that a parent branch measured 24·60 inches in girth, and that the thickened trailing portion, rooted in the ground, gave off four young trees, two of which girthed respectively 51·10 and 43·10 inches, the other two being about 40 and 23 inches.

On the 3rd November 1892 I took careful measurements of the trunk, aided by Mr. F. R. Coles and Mr. M'Hattie, head gardener at Newbattle Abbey, with the following results:—

	Ft.	In.		Ft.	In.
Girth at the ground, . .	43	8	Girth about 5 ft. up, . .	20	3·6
,, about 1 ft. up, . .	37	0	,, ,, 6 ft. up, . .	19	6·9
,, ,, $2\frac{1}{2}$ ft. up .	27	8	,, ,, $6\frac{1}{2}$ ft. up, .	19	1·5
,, ,, 3 ft. up, . .	25	9·6	,, ,, 7 ft. up, . .	18	5·8
,, ,, 4 ft. up, . .	23	1·6	,, ,, $7\frac{1}{2}$ ft. up, .	18	7
,, ,, $4\frac{1}{2}$ ft. up, .	21	11·6			

Circumference of the foliage (taken 1889), . .	400 feet.
Average diameter of foliage ,, . .	130 ,,
Longest horizontal branch ,, . .	72 ,,

The seven upper girths were taken with a 24 feet Chesterman steel tape, the base from which their position was fixed being a line marked with white paint at 6 feet 6 inches. The four lower girths, taken with an ordinary 66 feet tape, are less reliable, as they encounter the sloping base. The measurement at the ground was taken by a tape laid on the roots close to the rise of the base. The circumference of the foliage was got by measuring along the ground with a tape under the extremities of the branches, but disregarding those that projected overhead decidedly beyond the mass. The result may be somewhat unduly increased by including the foliage of the secondary trees, which cannot be separated from the general mass. The tree is perfectly sound and healthy, making long annual shoots, and the foliage in summer is so dense as to completely conceal the stem and branches except at a small opening on one side.

(*b*) Eccles Beech, Dumfriesshire. — Mr. Hutchison quotes the girths in 1869 as 26 feet at 2 feet; 20 feet at 4 feet; 25 feet at 7 feet; 17 feet at 16 feet; with a spread of branches of 100 feet, and a height of 65 feet. Sir R. Christison some years later says the trunk is only 4 feet high, and that at the sharply defined narrowest point, 2 feet up, the girth is 21 feet. He describes it as little inferior to the Newbattle beech, except in height and in the length of the trunk.

(*c*) Belton Beech, East Lothian, in 1863, girthed 19 feet 4 inches at 6 feet; 17 feet 8 inches at 9½ feet: and in 1880, 32 feet 8 inches at 1 foot; 20 feet 4 inches at 5 feet, with a 31 feet bole and a height of 63 feet, "a very magnificent specimen."—Mr. Hutchison.

(*d*) Methven Castle Beech, Perthshire, deserves notice for its general size and great height, although the girth at 5 feet is not so much as in the others. Colonel Smythe has furnished the following measurements:—

	Ft.	In.		Ft.
Girth at the ground, . .	37	0	Diameter of foliage, . . .	110
,, 1 ft. up, . . .	26	0	Longest horizontal branch, .	57
,, 3 ft. up, . . .	18	9	Bole, ...	18 to 20
,, 5 ft. up, . . .	16	3	Height, about	120
,, 6 ft. up, . . .	15	10		
,, 7 ft. up, . . .	15	7		

(*e*) KNOLE BEECH, KENT.—This celebrated tree girthed 24 feet at 3 feet; 27 feet at 10 feet; height, 105 feet; extent of boughs, 123 feet; solid timber, 498 feet.—Strutt, 1822.

(*f*) ROLLE BEECH, DEVON.—A gigantic tree, girthing 30 feet 7 inches at 3 feet; 25 feet 3 inches at 5 feet; height, 94 feet; branch-spread, 86 feet; cubic contents, 988 feet.—J. Barrie, forester, 1889.

1. RATES OF GIRTH-INCREASE IN BEECHES OF KNOWN AGE.

(*a*) Seven beeches at Stratton, Norfolk, grown from seed. Measured by Mr. Marsham, 1776. Five years taken from age (35) to allow for growth to 5 feet in calculating the rate.

	Age.	Girth at 5 ft.	Rate for 30 years.	Increase in 1776.
		Ft. In.		
No. 1, . . .	35	3 9·1	1·50	1·50
No. 2, . . .	35	3 9·7	1·52	2·50*
Five others of same age, . .		...	...	1·50

* This extraordinary growth he believed to be due to washing the stems three to five times a week in the spring, first with a stiff shoe-brush, afterwards with coarse flannel. The others were not washed.—Philosoph. Trans., 1777, p. 12.

(*b*) Beech at Bargaly, Kirkcudbrightshire, planted 1697 (Dr. Walker, 1780).

	Period.	Increase at 4 ft.	Rate.	Height.
	Years.	Inches.	Inch.	Feet.
1697 to 1780, .	83	96	1·15	80

(*c*) Two in Edinburgh Botanical Garden, planted 1821 when 5 or 6 years old. Measured, at 5 feet up, from 1878 to 1892 annually by Sir R. and D. Christison.

	No. 1.			No. 2.		
	Period.	Increase.	Rate.	Period.	Increase.	Rate.
	Yrs.	In.	In.	Yrs.	In.	In.
1821 to 1877, .	57	72	1·25	57	60	1·05
1878 to 1892, .	14	14	1·00	14	14	1·00
Average,	71	86	1·21	71	74	1·04

(*d*) Two tall beeches, 100 feet high, with long boles and small heads of foliage, in a grove at Craigiehall, Cramond. Age ascertained in 1878 by counting the rings in felled specimens, by Sir R. Christison. Subsequent measurements by him and by D. Christison. Five years deducted from their age for growth to 5 feet.

	No. 1.			No. 2.		
	Period.	Increase.	Rate.	Period.	Increase.	Rate.
	Yrs.	In.	In.	Yrs.	In.	In.
1758 to 1878, .	120	61·75	0·51	120	71·85	0·59
1878 to 1888, .	10	4·90	0·49	10	6·40	0·64
Average, .	130	66·65	0·51	130	78·25	0·60

(*e*) Beech at Cramond House, Midlothian, 100 feet high, 16 feet in girth at 5 feet up. Age ascertained by counting the rings on a fallen limb, 10 feet 2 inches in girth at 3 feet from its axilla, which was 33 feet above ground, and adding 40 years for growth up to that height.—Sir R. Christison, 1878.

Age, between 200 and 215 years. Rate, at least, 0·91.

(*f*) Beech at Craigiehall, 15 feet 9 inches in girth at 5 feet up where narrowest (16 feet, at least, allowing for loss from a gap). Rings counted by Sir R. Christison, 1878.

Age, 130 years. Rate, 1·53 inch.

(*g*) From Mr. Hutchison's Table.

Situation.	Date.	Age.	Girth at		Rate at	
			1 Ft.	5 Ft.	1 Ft.	5 Ft.
		Yrs.	Ft. In.	Ft. In.	In.	In.
Binning, East Lothian, .	1878	173	20 3	13 9	1·40	0·95
Craighall, Perth, . . .	1879	129	16 0	13 10	1·49	1·28

2. RATES FROM GIRTH MEASUREMENT IN TREES OF UNKNOWN AGE.

(*a*) From Mr. Hutchison's Table.

	Last Observation.	Period.	Girth.		Increase.	Annual Rate.
		Yrs.	Ft.	In.	In.	
Polloc, Renfrew, .	1879	16	13	4	26	1·62 at 5 ft. up
Do. do.	,,	,,	14	8	24	1·50 ,,
Shawholm, do.	,,	,,	13	5	23	1·44 ,,
Leslie, Fife, . .	,,	51	16	8	67	1·01 at 3 ft. up
Tullibody, Perth, .	...	9	16	6	25·5	2·83 at 1 ft. up

(*b*) Beech at Dalswinton, Dumfries, first measured by Mr. Leny and Sir R. Christison in 1857. Although its rate has decreased, the tree is now (April 1893) in splendid condition, and perfectly healthy. Girth at 6 feet, 13 feet 6½ inches.

	Girth at 3½ feet.		Number of Years.	Rate.
	Ft.	In.		In.
1857	11	11	...	...
1875	13	2½	18	0·86
1887	13	11¾	12	0·77
1892	14	2¾	5	0·60
			35	0·80

(*c*) Young and middle-aged beeches at various localities, at 5 feet up.

SITUATION.	Date.	Period.	Girth.		Increase.	Rate.	OBSERVER.
		Yrs.	Ft.	In.	In.	In.	
Edinburgh Arboretum, .	1892	4	1	2	4·90	1·25	D. Christison
Do. do.	,,	4	1	3	5·25	1·31	do.
Manor House, Clifton, .	1890	3	6	4	..	0·95	Dr. Beddoe
Annat Lodge, Perth, .	1889	1	7	1	..	1·05	Dr. Buchanan White
Chantry, Bradford-on-Avon, ...	1892	1	7	11	..	1·20	Dr. Beddoe
Do. do.	,,	1	19	8	..	1·25	do.
Annat Lodge, Perth, .	1889	1	10	7	..	0·70	Dr. Buchanan White
Craigiehall, W. Lothian,	1887	10	11	11	..	0·81	D. Christison

(*d*) Rate of the great Newbattle beech for fifteen years ending November 1892, at a marked line 6½ feet above

ground. Original measurement by Sir R. Christison; subsequent ones by me. Given in feet, inches, and tenths of an inch.

Girth Nov. 1892.	Increase.							Annual Rate.			
	1880 to 1885.	1886 to 1888.	1889.	1890.	1891.	1892.	Total.	First 6 years.	Next 3 years.	Next 4 years.	13 years.
Ft. In. 19 1·5	In. 2·60	In. 1·35	0·30	0·30	0·45	0·50	5·50	0·43	0·45	0·39	0·42

3. Estimation of Age in Ancient Beeches.

The data yield a greater range than in the oaks. In Mr. Hutchison's cases we do not know whether the measurements were taken at a marked line. On the whole, however, the figures are confirmed by the results in the other tables.

Estimation of Age of the Newbattle Beech.—Taking the ascertained rate of 0·40 inch for the last 14 years, at a girth of 19 feet, and supposing, according to De Candolle's theory, that the rate had always been nearly the same except in early youth, we get about 550 for the age; but how fallacious this would be is actually proved by measurements taken above a century ago, as will presently appear. Reverting, therefore, to the mode of estimation already explained, let us first take the data which show the most rapid growth. These we find in the large beech at Craigiehall (1 *f*). Fortunately for us, though unluckily for the tree, a violent storm tore away one of the large limbs, producing a gap 4 feet wide in the 9 feet long stem, right down to the pith. In 1879 Sir R. Christison describes the tree as 70 feet high, luxuriant in foliage, with branches extending 50 feet from the trunk to north, south, and west, and only deficient to the east on account of the gap. In this gap he was able to count the rings, at a height of about 6½ feet, throughout the whole radius of 32½ inches, except the inner five, which were decayed, and six more, beginning at a foot from the centre, in which the rings were too indistinct to be counted. It is easy to make allowance for these, however, and dividing the radius, in the diagram drawn up by Sir Robert, into spaces of

$2\frac{1}{2}$ inches, we get the following number of rings in each space:—

Spaces.	No. of Rings.	Spaces.	No. of Rings.	Spaces.	No. of Rings.	Spaces.	No. of Rings.	Spaces.	No. of Rings.
Inner	12	4th	7	7th	7	10th	9	Outer	14
2nd	8	5th	7	8th	7	11th	8	Additional	2
3rd	8	6th	8	9th	7	12th	12		
								Total,	116

Adding the liberal allowance of 14 years for growth up to $6\frac{1}{2}$ feet, we got 130 years for the age of the tree. Its girth was 15 feet 9 inches, but must have been considerably more before the gap was made. Taking it, however, at only 16 feet, and allowing but 5 years for growth up to 5 feet, we establish the fact that a beech *may* attain 16 feet in girth at the narrowest part of the stem within 130 years, thus growing throughout at the annual average rate of 1·53 at the very least. The figures also show that the rate did not fall off till the tree was about 15 feet in girth, and Sir Robert ascertained by annual girth-measurement that at the end of its career, and in spite of the terrible injury, the tree was still growing at the rate of fully an inch annually. This result is so far confirmed by Mr. Marsham's two beeches (1 *a*), which grew at the rate of 1·50 for 35 years.

Valuable assistance in estimating the age of the Newbattle beech is obtained from Prof. Walker's measurements in 1789. He describes "the large beech at Newbattle Abbey, standing on the lawn behind the house," as vigorous and healthy, with an immense head, a span of branches of 89 feet, and a girth of 17 feet at 4 feet up. It is now 23 feet 1 inch at the same height, showing a growth of 6 feet in a century, or at the average annual rate of 0·72 inch. But from what we know of its present form, the stem must have had much the same girth, at 6 feet 6 inches, a century ago, as the Craigiehall stem had at the same height. Thus we get 130 for the *possible* age of the Newbattle beech in 1789, and adding the 103 years to 1892, 233 for its *possible* present age.

Admitting that the rate of the Craigiehall tree is quite extraordinary, and making an estimate from our more

moderate data, it is evident that when 12 feet in girth the tree might easily have been 154 years old. Now the rate for the last 13 years is known to be 0·40 inch, and that of a 12 feet tree being known to be 0·80 inch, if we take 0·50, or half an inch, for the average rate between 12 and 19 feet—a very moderate estimate, allowing for the gradual diminution of the rate with age—the age comes out as about 320.

Again, Sir Robert Christison ascertained the age of the splendid beech at Cramond (1 *e*) to be between 200 and 215, with a girth of 16 feet at 5 feet: allow the Newbattle tree to have attained the same size at the same age—it is now 20 feet at that height; take the ascertained recent rate of 0·40 at 6 feet 6 inches as having lasted during the whole time the tree took to grow from 16 to 20 feet in girth at 5 feet, and we get 120 to add to, say, 210, or 330 in all. But the rate must be greater where the tree girths 20 feet than where it is only 19 feet, and it must in all probability be greater in proportion as we recede from the present time. Hence, by this computation, the tree cannot be much, if at all, above three centuries old. Altogether, we may conclude that the age is not likely to exceed 320 years, and may *possibly* not be above 250.

The rate of two of the secondary trees springing from one of the rooted branches of the giant I ascertained for four years, as follows:—

	Girth.	Increase.				Average Rate.
	April 1889.	1889.	1890.	1891.	1892.	
Parent branch, . .	24·70	0·00	0·00	0·00	0·00	0·00
Young tree No. 1, .	48·00	0·60	0·45	0·60	0·55	0·52
Do. No. 2, .	38·85	0·65	0·90	1·00	1·50	1·01

It thus appears that the young trees are growing vigorously, while their parent branch has ceased to grow. The numerous young trees, of which these two are but examples, must therefore be attracting much of the nourishment that ought to go to the parent tree, and it is to be feared that as the youths grow up they may gradually starve and kill the parent. It is a serious

question, therefore, whether they should not be removed, bearing in mind the risk there might be of exposing the giant more freely to the assaults of the wind, a danger which could probably be avoided by removing the secondary trees gradually.

III. THE SPANISH CHESTNUT (*Castanea vesca*).

According to Mr. Hutchison's tables the Spanish chestnut comes next to the oak in productiveness of large trees in Scotland, at least as far as girth measurement goes. It is necessary, however, to deduct two from the eighteen which figure in his list as above 17 feet in girth at 5 feet, because they measure less than 17 feet lower down, and in four others the same fault may be suspected, although the data are insufficient to prove it. I have placed these six, therefore, in a separate list, and have added to the first list two others which are entitled to a place in it.

Spanish chestnuts, 17 feet in girth and upwards at 5 feet up, or at the probable narrowest point. Chiefly from Mr. Hutchison's Table of 116 Scottish specimens (Trans. H. and Agr. Soc. Scot., 1879).

	Girth.		Height of Bole.	Height of Tree.	Spread of Branches.
	Ft.	In.	Ft.	Ft.	Ft.
Newbattle, Midlothian, . .	17	0	...	80	...
Lochryan, Wigtown, . .	17	2	10	60	...
Gask, Perth, ...	17	2	...	35	...
Newbattle, Midlothian, .	17	10	...	75	...
Ardkinglass, Argyll, . .	17	11	...	35	42
Duntarvy, West Lothian, .	18*	0	...	85	...
Castle-Menzies, Perth, . .	19	2	...	60	...
Inveraray, Argyll, . .	19	4	...	85	...
Ardgartan, Argyll, . .	20	8	25	90	...
Bemersyde, Roxburgh, . .	21	6	...	50	...
Camnethan, Lanark, . .	22	0	10	70	...
Not in Mr. Hutchison's List.					
Castle-Leod, Ross, . .	19	6	...	...	...
Keir, Perth, ...	20	0	...	...	...
Highest in Mr. Hutchison's List.					
Marchmont, Berwick, . .	14	6	32	102	...
Greatest Branch-Spread.					
Ardkinglass, Argyll, . .	15	9	...	90	72
Tillicoultry, Clackmannan, .	16	0	...	75	72

Number exceeding 15 feet in girth at 5 feet.

15 to 16 feet,	9	Probably all these would be retained as above 15 feet at the *narrowest* girth, but several would be reduced from the higher to the lower ranks.
16 ,, 17 ,,	11	
17 ,, 18 ,,	8	
18 ,, 19 ,,	3	
19 ,, 20 ,,	5	
Above 20 ,,	3	
Above 15 feet,	39	
Above 20 feet in girth at 1 foot,		21

Except the Marchmont tree none exceed 90 feet in height, and only four reach it.

The trees, 17 feet in girth and upwards at 5 feet, excluded from the table are:—

	Ft.	In.	
Taymouth, Perth,	17	5	Only 14 ft. 6 in. at 3 ft. in 1862.
Kirkmichael, Ayr,	17	0	Only 15 ft. 6 in. at 6 ft. in 1862.
Kirkconnel, Dumfries,	18	7	Only 10 ft. at 1 ft.; surely some mistake here.
Menteith, Stirling,	18	6	Only 16 ft. at 3 ft.
Dunipace, Stirling,	19	6	Bole only 6 ft.
Murthly, Perth,	17	7	Bole not given, and no other details.

Scottish Chestnuts. — 1. Ardgarten Chestnut. — Probably this was the finest and most promising Spanish chestnut in Scotland until a few years ago. In 1867 Sir Robert Christison described it as having a tall, beautiful trunk, without humps, 20 feet in girth at 5 feet up. Unfortunately, a storm in 1875 broke it over, and reduced its height from 100 to 70 feet. He found, nevertheless, in 1877 that the girth had increased 8 inches since 1867, and that the foliage was still dense and healthy. In 1879, Mr. James Gordon, gardener at Luss, found the girth at 7 feet up to be 19 feet 10½ inches.

2. Keir Chestnut.—Sir Robert described this in 1878 as venerable and staghorned, with scanty foliage and many rugged humps. At 4 feet up, where most free from these, it girthed 20 feet.

3. Edmonstone Chestnut.—Probably the largest near Edinburgh. Sir Robert found it to be 16 feet 10 inches in girth 5 feet up in 1879.

4. Finavon Chestnut, Forfarshire.—One of the largest deciduous trees in Scotland, of which we have a well-

authenticated record. It was solemnly measured in 1744 before two justices of the peace, with the following results:—

	Ft.	In.
Girth of trunk 6 inches up,	42	8½
,, ,, at narrowest,	30	7
,, top of trunk, where grains branch,	35	9
,, largest grain,	23	9
,, smallest grain,	13	2⅜

These dimensions are well borne out by a print of 1750, a copy of which was sent to Sir Robert by Mr. Hutchison. The tree was in a state of decay when measured, but its remains were not cut down till about 35 years ago.

5. KINFAUNS CHESTNUT.—Another veteran of the past, cut down in 1760. Girth at 4 feet up, 22 feet 6 inches (Dr. Walker).

ENGLISH CHESTNUTS.—1. TORTWORTH CHESTNUT, GLOUCESTERSHIRE.—Even the Finavon giant seems dwarfed by this wonderful tree, of which the following measurements have been published:—

(*a*) Girth at 6 feet up, 51 feet 6 inches, stem not hollow, but the boughs few and small (Bradley's Phil. Acct. of Works of Nature, 1739).
(*b*) Girth at 6 feet up, 46 feet 6 inches in 1759 (Mr. R. Marsham).
(*c*) In 1776 girthed 50 feet at 6 feet, and one of its limbs 28½ feet at 5 feet from the stem (Strutt's Sylva Brit., 1822).
(*d*) In 1877 it still survived as a ruin, with a hollow trunk, throwing out shoots to a height of 40 feet. When carefully measured for Mr. Hutchison, the girth at 1 foot was 45 feet 9 inches, and at 5 feet, 47 feet 9 inches.

2. In LORD PETRE'S PARK, Writtle, Essex, a chestnut 42 feet 5 inches in girth at 3½ feet, the narrowest part; 46 feet 1 inch at 5 feet; 49 feet 5⅞ inch at 6 feet.—Mr. R. Marsham, 1755.

3. Largest of "THREE SISTERS," BACHYMBYD, NORTH WALES (Mr. Cornwallis West of Ruthin Castle, 1878). Girth at one foot, 36 feet 6 inches; at 5 feet, 34 feet 6 inches; at 7 feet, 35 feet 4 inches. Height about 70 feet.

4. COBHAM PARK CHESTNUT.—35 feet 2 inches at the ground, 29 feet at 3 feet, 33 feet at 12 feet, and 40 feet at the division into limbs.—Strutt's Sylva Brit., 1822.

5. CROFT, HEREFORD.—25 feet 6 inches at 5 feet up.—Trans. Woolhope Club, 1870.

RATES OF GIRTH-INCREASE.

1. Six Spanish chestnuts, Kirkconnel, Dumfries, planted in 1748 (from family records; Mr. Maxwell Witham to Mr. Hutchison, 1878).

	Date of Measurement.	Girth at		Rate at		Period of Years.
		1 Ft.	5 Ft.	1 Ft.	5 Ft.	
		Ft. In.	Ft. In.	In.	In.	
Average of six, . .	1878	16 6	12 3	1·52	1·14	130
The largest, . .	1878	21 0	16 0	1·93	1·47	130

2. Two planted at Rosebank, Midlothian, 1729, girthed 5 feet 4 inches in 1761. Rate for thirty-two years, 2 inches. One at Lochnell, Argyllshire, thirty-six years old, girthed 5 feet. Rate 1·66 inch. All at 4 feet up (Dr. Walker).

3. Young or middle-aged trees, from girth measurements at 5 feet up.

SITUATION.	Date.	Period.	Girth.	Rate.	Authority.
		Yrs.	Ft. In.	In.	
Dunkeld, Perth, .	1889	1	0 7	1·12	Mr. Fairgrieve
Annat Lodge, Perth,	,,	1	4 1	1·45	Dr. Buchanan White
Edin. Bot. Garden,.	1892	15	7 0	0·90	D. Christison
Annat Lodge, Perth,	1889	1	8 9	0·90	Dr. Buchanan White

4. One at Dalswinton, Dumfries, first measured 1836, by Mr. J. M. Leny and Sir R. Christison, at 5 feet. In April 1893 it looks very shabby, and has probably long been failing, as the decreasing rate also testifies.

Girth, 1836, . Ft. In. 9 6	Period.	Girth.	Rate.
	Years.	Ft. In.	Inch.
1836 to 1875, . .	39	11 9	0·70
1875 to 1887, . .	12	12 4	0·58
1887 to 1892, . .	5	12 6¾	0·55

5. Two at Castle-Menzies, Perth. First measured by

Sir R. Christison, 1879; re-measured by Sir R. Menzies, 1892, at 5 feet up.

	Period.	Girth, 1892.	Rate.
	Years.	Ft. In.	
No. 1, . . .	13	14 0	1·00
No. 2, . . .	13	14 8	1·23

6. Old chestnuts at 5 feet up.

SITUATION.	Girth.	Period.	Rate.	Authority.
	Ft. In.	Yrs.		
Polloc, Renfrew, . .	15 6	41	1·07	Mr. Hutchison's Table
Dumbarney, Perth, .	16 0	16	1·50	do. do.
Ardgarten, Dumbarton,	20 8	10	0·60	Sir R. Christison, 1879
Hevingham, Norfolk, .	14 8½	168	1·04	Mr. R. Marsham, 1780

From the above data the Spanish chestnut appears to be a quick grower, even when of very considerable size. The age of the Kirkconnel trees seems perfectly well ascertained from family records, and if we construct a scheme for the age of the deceased Finavon giant, 30 feet in girth at the narrowest, founded on the rate of the most vigorous of these, and on that of the Ardgarten tree, supposing the rate of the Finavon tree after passing the size of the Ardgarten one to be reduced to one-half of that of the latter, we get the following:—

Size.	Rate.	No. of Years.
0 to 192 inches	1·47	130
192 to 240 ,,	1·00	48
240 to 248 ,,	0·60	10
Possible least age of Ardgarten tree,		188
248 to 368 inches	0·30	400
Possible age of Finavon tree, . .		588

This estimate, however, is founded on the theory that a very large tree, 30 feet in girth, would begin to grow slowly at the same size as that at which a tree never exceeding 20 feet in girth began to grow slowly. But is

it not more likely that the greater tree, like the lesser one, would not slacken in its rate till within a few feet of attaining its final girth? In that case about four centuries, or even less, seems not at all an impossible period for a Spanish chestnut, 30 feet in girth, to attain its full dimensions.

The history of the Finavon tree, confirmed by that of the Tortworth giant, proves that the species is slow to decay. The drawing of 1750 shows that even then the great majority of the branches were leafless, and ten years later Dr. Walker describes only "a great part of the trunk and several branches" as remaining. Nevertheless it was not till 1858, a century later, that it was pronounced dead and was cut down. The whole period of decay cannot have been much less than two centuries.

The Dalswinton chestnut (No. 4) is an example of what I have noticed in trees of various species, that a considerable increase in girth may continue after serious signs of failure in the branches.

IV. The Ash (*Fraxinus excelsior*).

Scottish ashes above 18 feet in girth at 5 feet from the ground. Chiefly from Mr. Hutchison's Table of 108 Scottish ashes (Trans. H. and Agr. Soc. Scot. xii., 1880).

Situation.	Girth.		Height of Bole.	Height of Tree.	Spread of Branches.
	Ft.	In.	Ft.	Ft.	Ft.
Kinnaird, Forfar,	18	3	50	70	...
Ochtertyre, Perth,	18	3	40	85	...
Darnaway, Moray,	18	5	10	60	...
Do. do.	18	8	13	50	...
Yair, Selkirk,	19	9	...	115	...
*Cawdor Castle, Nairn,	20	8	...	50	84
Highest Ashes.					
Cockburnspath, Berwick,	11	6	18	103	...
Gilmerton, Midlothian,	9	0	36	108	...
Brahan Castle, Ross,	12	8*	17	110	...
Scone, Perth,	11	2	40	115	...
Milne-Graden, Berwick,	12	2	55	121	...
Mount Stuart, Bute,	9	6	36	134	...

* Mr. Charles Clark, forester (Conifer Conf. Statistics, 1891).

Number 100 feet high and upwards, . . 10
From 90 to 100 feet, ... 13

Number above 15 feet in girth at 5 feet up.

15 to 16 feet,	5
16 ,, 17 ,,	2
17 ,, 18 ,,	1
18 ,, 19 ,,	4
19 ,, 20 ,,	1
Above 20 ,,	1
Total,	14
Above 20 feet in girth at 1 foot up,	16

The Yair tree, perhaps the largest thriving ash in Scotland, is difficult to measure, as the ground on which it stands is fully 4 feet higher on the one side than the other. On the 21st June 1893, measuring from the lower side, I found the girth to be 21 feet 6 inches at 5 feet up, 18 feet 2 inches at 6 feet, and 17 feet 10 inches at 8 feet. The circumference of the foliage, which was somewhat thin but healthy, was nearly 300 feet.

The number of remarkable ashes in a flourishing condition is not great, but there is good evidence that the species has produced in the past several trees of the largest size of which we have any record in Scotland. Besides two, which are equalled in the present day,—one at Carnock, Stirlingshire, recorded by Strutt in 1825 as being 31 feet in girth at the ground, 19 feet 3 inches at 5 feet, and 21 feet 6 inches at 9 feet; the other on Inch Merrin, Loch Lomond, recorded by Dr. Walker in 1784, as 21 feet 8 inches at 4 feet,—Dr. Walker mentions three that greatly exceeded these dimensions, (1) a second specimen on Inch Merrin, 28 feet 5 inches at 5 feet; (2) the celebrated ash at Kilmalie, Inverness-shire, burnt to the ground by the soldiery in 1746, the circuit of which was still traceable in the same year, the remains being from several inches to a foot high all round, measuring 58 feet, with cross diameters of 21 and 17 feet, and described by one who remembered it before its destruction as dividing into three great arms at a height of 8 feet; (3) the great ash at Bonhill Place, Dumbartonshire, vestiges of which still remain, described by Dr. Walker in 1784 as girthing 34 feet 1 inch at 4 feet, 21 feet 3 inches at 8 feet, and 22 feet 9 inches at 12 feet, where it divided into three arms (not original, but the result of pollarding), 12, 11, and 10 feet in girth; a room in the trunk was 9 feet 1 inch

in diameter, and eighteen people could sit on a hexagonal bench round a table in the middle. Another great ash was blown down at Bonhill Churchyard in 1845. The circle round the base was 63 feet; girth at 3 feet, 26 feet 6 inches; branch spread, 100 feet; height, 113 feet.

My own recollection of another ruined ash at Dalswinton, Dumfries, seen in my youth, is that it was the largest stump of a tree I have ever seen in Scotland. Unfortunately no record of its size has been kept, but Mr. W. M. Leny, the proprietor, writing in 1875, says his recollection was that the last measurement was 39 feet.

But the most satisfactory example is at Logierait, Perthshire, as, although much ruined, enough remains to prove the accuracy of the measurements given in the Statistical Account of Scotland in 1845, when it was still comparatively flourishing. The girth was then 53½ feet at the ground, 40 feet at 3 feet, 22 feet at 11 feet; and the height, 60 feet. The upper part had been carried away, the trunk was hollow, but "the profusion of foliage attracted the eye at a distance to its enormous proportions." The Rev. Mr. Andrew Meldrum, minister of the parish, has supplied me with a drawing, measurements, and description, from which it appears that only half the circumference of the trunk remains, and its height is reduced to 15 feet. The semi-circumference measures 29 feet, and its base-line 18 feet, at the ground. At 3 feet the diameter is 13 feet; at 6 feet, 9 feet; and at 11 feet, 7 feet 6 inches. The tree when complete, therefore, could hardly have girthed less than 30 feet at 5 feet up, and it must have been one of the largest trees in Scotland of which we have a reliable record.

Too late for insertion in the proper place, I have received measurements, taken expressly for me, of the *Capon Oak*, near Jedburgh, one of the very largest oaks in Scotland,—"it covers an area of between 80 and 90 feet diameter. The gnarled stem girths 39 feet near the ground, 23 feet at 4 feet up, the narrowest point, and after giving off a large limb forks at 6 feet up, one limb girthing 10 feet 9 inches, and the other 16 feet 4 inches, a little above the fork" (Mr. T. Caverhill, factor to Lord Lothian).

RATE OF GIRTH-INCREASE.

Rate of Girth-Increase from measurements 5 feet up.

SITUATION.	Last Observation.	Girth.	Period.	Rate.	Authority.
		Ft. In.	Yrs.		
Edin. Arboretum, .	1892	0 10·30	5	0·91	D. Christison
Do. do.	1892	1 1·60	1	1·35	do.
Craigiehall, W. Lothian,	1890	12	13	0·37	do.
Biel, E. Lothian, .	1879	13 2	67	0·30	Mr. Hutchison's Table
Dalswinton, Dumfries,	1887	13 3	30	0·58	D. Christison
From measurements 4 feet up.					
Lord Methuen's Ash, Methven, Perth, .	1891	6	28	0·64	Col. Smythe
Col. Robert's Ash, do.	1892	7 2	29	0·69	do.
St. George's Ash, do.	1892	5 3	29	0·69	do.
Rate from known age of tree, at 3 feet up.					
Colonel Robert's Ash, Methven, Perth, .	1883	7	83	1·01	do.
St. George's Ash, do.	1845	2 9	40	0·83	do.

At uncertain height, West Felton, Salop, 1880. (Mr. J. Dovaston.)

Date.	Period.	Girth.	Increase.	Rate.
	Years.	Ft. In.		
1880	69	12 7	72	1·04

From known age, at 4 feet up.

SITUATION.	Last Observation.	Girth.	Period.	Rate.	Authority.
		Ft. In.	Yrs.		
Kames, Bute, . .	1771	10 10	80	1·62	Dr. Walker
Mellerstain, Berwick,	1795	8 1	80	1·21	do.
Rate by counting Rings in a fallen tree, at 3 feet.					
Rothesay, Bute, . .	...	17 5	220	0·95	do.

The rates yield in general rather low results, although a few are higher than in the oak. The very slow rate of the Craigiehall ash, 12 feet in girth, is accounted for by obvious injury from the great frosts of 1879, as in 1878 it increased 0·70, and never more than 0·45 thereafter, generally much less. Dr. Walker describes an ash at the ferry over the Tay, near the Church of Logierait, well known in the country as "the Ash Tree of the Boat of Logierait," which in July 1770 was a healthy, well-shaped tree, 16 feet in girth at 4 feet up, and about 70 feet high. It is difficult to see how this can be any other than the

tree of which the stump still remains, and which we have shown must have been at least 30 feet in girth at 5 feet up, and was, therefore, considerably more at 4 feet. This would give a rate for about seventy-five years of something between 2½ and 3 inches, which seems incredible, unless trees of gigantic size have the power of developing, with great rapidity, the conical swelling which is required to support their increasing weight.

V. The Sycamore (*Acer pseudoplatanus*).

This species, a favourite in Scotland from its beauty and power of standing our strong winds, seems but rarely to have reached a gigantic size, as Mr. Hutchison's table contains only one 20 feet in girth at 5 feet up.

Scottish sycamores above 17 feet in girth at 5 feet from the ground. From Mr. Hutchison's Table of 153 Scottish sycamores (Trans. H. and Agr. Soc. Scot. xii., 1880).

Situation.	Girth.		Height of Bole.	Height of Tree.	
	Ft.	In.	Ft.	Ft.	In.
Castle-Menzies, Perth,	17	8	15	90	3
Newbattle, Midlothian,	18	3	12	(?)	
Castle-Menzies, Perth,	18	4	35	104	0
Birnam, Perth,	18	11	10	75	0
Newbattle, Midlothian,	19	8	(?)	(?)	
Tyninghame, East Lothian,	20	10	37	80	0
Trees of substantial girth which are 100 feet or more in height.					
Castle-Menzies, Perth,	13	6	28	100	0
Broxmouth, East Lothian,	15	2	50	100	0
Beil, East Lothian,	12	7	50	100	0
Braehead, Midlothian,	12	7	14	101	0

Number between 90 and 100 feet in height, 11
,, 100 feet or upwards, ... 6
Greatest spread of branches (eighteen given), 90 ft.

Number above 15 feet in girth at 5 feet.

15 to 16 feet,	8
16 ,, 17 ,,	3
17 ,, 18 ,,	3
18 ,, 19 ,,	4
19 ,, 20 ,,	1
Above 20 ,,	1
Total,	20

Between 20 and 30 feet at 1 foot, . . 9
Above 30 feet at 1 foot, ... 1

SCOTTISH SYCAMORES. — NEWBATTLE SYCAMORE.—There is a larger sycamore here than any recorded above, although it is in a very ruinous condition. On 3rd November 1892, I measured it carefully with the assistance of Mr. F. Rhenius Coles. It has a short "bumpy" stem, 34 feet in girth, where it springs, without buttresses, from the ground. A little higher it is 30 feet. It then suddenly narrows to 21 feet 9 inches at 4 feet, but rises again to a considerable height with little or no diminution. The narrowest I could get, where also most free from bumps, was 21 feet 4 inches at 6 feet 8 inches up. This is apparently the tree described by Dr. Walker in 1789 as still sound, but with an aspect of great antiquity, measuring 24 feet 4 inches at 2½ feet, and 18 feet 7 inches at 4 feet.

KIPPENROSS SYCAMORE.—Mr. Hutchison mentions this as long reputed to be "the largest tree in Scotland," and said to be 22 feet 6 inches in girth at 5 feet up in 1798. It was snapped across by a gale, a few feet from the ground, not many years ago. Probably it is the same tree as that described by Sir R. Christison in 1880. A plate on the trunk certifies its girth at the narrowest point to have been 19 feet 6 inches, and he found it still to measure 18 feet 6 inches at 5 feet up, notwithstanding an evident loss of substance.

CASTLE-MENZIES SYCAMORE.—Sir Robert Menzies has sent me, December 1892, the following girths of his finest specimen:—At 1 foot, 28 feet 4 inches; at 3 feet, 22 feet 9 inches; at 5 feet, 19 feet 2 inches.

ENGLISH SYCAMORES.—Perhaps the species was, formerly at least, not such a favourite in England as in Scotland, as Mr. Strutt seems to have been struck with the beauty of the Scottish specimens. His only English example, at Cobham Park, was 26 feet in girth at the ground, and 94 feet high.

RATE OF GIRTH-INCREASE.

The mature sycamore does not lend itself well to

accurate girth measurement, as the bark is not only very rough, but is apt to scale off. As far as my data go, however, this species seems to be of slow growth in girth, although Mr. Hutchison thinks it grows quickly in height. The lower measurements—at 3 feet and 1 foot—indeed yield better results, possibly indicative of rapid growth in the conoid base, but measurements there are little reliable, unless the position has been carefully marked.

Rate of Sycamores of various Ages.

Situation.	Last Observation.	Girth.		Period.	Rate.	Authority.
At 5 feet up.						
No.	.	Ft.	In.	Years.	In.	
1. Edin. Arboretum, .	1892	1	3	6	1·14	D Christison
2. Do. do.	,,	1	4	6	1·19	do.
3. Edin. Bot. Garden, .	,,	5	3	14	0·35	do.
4. Craigiehall, Midloth'n,	1890	10	10	13	0·44	do.
5.*Edin. Arboretum, .	1892	11	3	15	0·26	do.
6. Lochwood, Dumfries,	1879	13	4	106	0·52	R. Hutchison
At 4 feet up.						
7. Redhall, Midlothian,	1879	10	2	81	0·30	do.
8. Do. do.	,,	11	9	81	0·36	do.
At 3 feet up.						
9. Birnam, Perth, . .	1879	19		16	0·56	do.
10. Rossdhu, Dumbarton,	,,	17		83	0·50	do.
11. Houston, Renfrew, .	,,	16	10	16	1·00	do.
At 1 foot up.						
12. Rossdhu, Dumbarton,	1879	22		16	0·75	do.

* Largest sycamore in the Arboretum. Shows symptoms of decay.

Aged trees at Castle-Menzies, taken at 5 feet by Sir Robert Christison in 1879, and by Sir R. Menzies in 1892.

	Date.	Girth.		Period.	Rate.
		Ft.	In.	Years.	
No. 1, . .	1892	12	5	13	0·30
No. 2, . .	,,	14	0	,,	0·30
No. 3, . .	,,	15	3	,,	0·79
No. 4, . .	,,	16	4½	,,	0·15
No. 5, . .	,,	18	9	,,	0·46

Another at Castle-Menzies, at several points, 1892.

	Girth.		Increase. 13 years.	Rate.
	Ft.	In.	In.	
At 2 feet, . .	28	4	4	0·30
,, 3 feet, . .	22	9	9	0·69
,, 5 feet, . .	19	2	10	0·77

Acer campestris.

Probably the largest in Scotland, in 1770, at Inveraray, was 7 feet 1 inch in girth at 4 feet.—Dr. Walker.

The rate of a young tree, 14 inches in girth, in the Edinburgh Arboretum in 1892 was 1·60 inch. — D. Christison.

VI. THE LIME (*Tilia europæa*).

The lime, as Mr. Hutchison remarks, is rarely grown in Scotland except as an ornamental tree, particularly for avenues. There appears to be no record of any remarkable lime which has disappeared.

Scottish limes above 17 feet in girth at 5 feet up. Chiefly from Mr. Hutchison's Table of 69 Scottish limes (Trans. H. and Agr. Soc. Scot., 1883).

SITUATION.	Girth.		Height of Bole.	Height of Tree.	Spread of Branches.
	Ft.	In.	Ft.	Ft.	Ft.
Ingliston, Midlothian, . .	17	0	20	83	...
*Monzie Castle, Perth, . .	17	10	...	...	...
Kinnaird, Forfar, . . .	18	1	6	62	...
Ferniehirst, Roxburgh, . .	18	3	...	...	...
Kinloch, Meigle, Perth, .	19	2	...	73	90
Ancrum House, Roxburgh, .	20	0‡	12	...	...
Kirkmichael, Dumbarton, .	23	1†	25	80	100
Highest Limes.					
Blairdrummond, Perth, . .	14	9	6	98	...
Newton-Don, Roxburgh, .	11	10	...	104	...

* Mr. G. Morgan, wood merchant, Crieff, April 1893.
† At 3 feet, no other girth given.
‡ At 5 feet, the narrowest.—Sir R. C., about 1877.
§ By Atkinson's Hypsometer, but I think the height is greater.—D. C., 1893.

Number above 15 feet in girth.

15 to 16 feet,	4
16 ,, 17 ,,	0
17 ,, 18 ,,	2
18 ,, 19 ,,	2
19 ,, 20 ,, or upwards,	3
Total,	11
Above 20 feet in girth at 1 foot,	9

The Kirkmichael tree I have included because, with its girth of 23 feet 1 inch at 3 feet, and a bole of 25 feet, it cannot fail to be above 17 feet at 5 feet, and may easily be above 20 feet. This tree, with its greater height and wider spread, may surely dispute the premiership which Mr. Hutchison gives to the Kinloch specimen, particularly as the latter is only 21 feet 2 inches at 1 foot, while the former is 23 feet 1 inch at 3 feet.

RATES OF GIRTH-INCREASE.

Situation.	Last Observation.	Girth. Ft.	In.	Period. Years.	Rate.	Authority.
From measurements at 5 feet up.						
1. Edin. Arboretum,	1892	0	11·5	6	0·73*	D. Christison
2 Do. do.	,,	0	11·0	6	0·56*	do.
3. Do. do.	,,	1	3·0	1	1·35	do.
4. Clifton, Gloucester,	1890	5	3·0	3	1·25	Dr. Beddoe
5. Polloc, Renfrew,	1881	11	3·0	23	0·91	Mr. Hutchison's Tables
From known age of Tree, at 5 feet.						
Kenmure, Kirkcudt.,	1883	10	11·0	183	0·71	Mr. Hutchison's Tables
Do. do.	,,	12	1·0	183	0 79	do.
Kinnaird, Forfar,	,,	12	8·0	200	0 76	do.
Do. do.	,,	18	1·0	200	1·08	do.

* In poor sandy soil.

VII. THE ELM (*Ulmus campestris* and *U. montana*).

Large elms in Scotland are of the *Wych* species, the biggest, *U. campestris*, at Eglinton girthing only 12 feet 4 inches at 5 feet (Hutchison); whereas the great elms of England are nearly all of the latter species.

Scottish elms above 17 feet in girth, at 5 feet up, from

Mr. Hutchison's Table of 105 Scottish elms. (Trans. H. and Agr. Soc. Scot. xv., 1883, p. 84).

SITUATION.	Girth.		Height of Bole.	Height of Tree.	Spread of Branches.
	Ft.	In.	Ft.	Ft.	Ft.
Newbattle, Midlothian, .	17	11	...	...	...
Carronhall, Stirling, .	18	2	...	85	...
Kinfauns, Perth, . .	19	3	7 (?)	92	...
Highest.					
Biel, East Lothian, .	12	11	12	102	...
Remarkable spread.					
Strontian, Argyll, . .	15	2	(?)	63	120

Number between 90 and 96 feet high, . .	16
100 and upwards, ...	1

Number above 15 feet in girth.

From 15 to 16 feet, ...	4
,, 16 to 17 ,, ...	3
,, 17 to 18 ,, ...	0
,, 18 to 19 ,, ...	1
,, 19 to 20 ,, ...	1
Above 15 feet, .	9
Number above 20 feet at 1 foot, . . .	9

NEWBATTLE ELM.—This lofty, though failing, elm stands close to the great beech. In November 1892 I found it at 5 feet 6 inches, apparently the narrowest part, to be 17 feet 9 inches; and at 4 feet, 18 feet 1 inch. The head of foliage is still considerable, and is about 180 feet in circumference.

ENGLISH ELMS. — 1. MOOR COURT, HEREFORD.—"The finest in the country," 18 feet 10 inches at 5 feet up.—Trans. Woolhope Club, 1870.

2. SILVER HALL, ISLEWORTH, THAMES.—Two stems spring from a base, 13 feet 7 inches in diameter, close to the ground, indicating a girth of about 40 feet. At 3 feet the largest limb is 20 feet 4 inches in girth, and at 30 feet, 14 feet 4 inches; at 3 feet, the smallest limb is 14 feet 6 inches in girth.

3. HEVINGHAM PARK, NORFOLK.—At 4 feet, 29 feet 6 inches, in 1779.—Mr. Marsham.

4. BRADLEY, SUFFOLK.—At 5 feet, 26 feet 3 inches, in 1754.—Mr. R. Marsham.

5. Crawley, Sussex.—61 feet in girth at the ground, 35 feet in girth 2 feet up inside the hollow stem.—Strutt's Sylva, 1822.

6. Sprotborough Hall, Yorkshire.—*U. montana*, 18 feet 2 inches at 4 feet up, the narrowest of a 15 feet stem; branch-spread, 148 feet; height about 85 feet.—Mr. Malcolm Dunn, 1891.

Rate of Girth-Increase.

From measurements at 5 feet up.

Situation.	Last Observation.	Girth.	Period.	Rate.	Authority.
		Ft. In.	Years.		
Edin. Arboretum, .	1892	1 8·85	5	1·62	D. Christison
Do. do.	1891	1 4·45	4	1·44	do.
Bradley Ch., Suffolk,	1767	26 3·00	13	0·73	Mr. R. Marsham
Polloc, Renfrew, .	1881	14 8·00	69	0·66	Mr. Hutchison's Table

From measurements at 4 feet up.

Situation.	Date of Observation.	Girth.	Period.	Increase.	Rate.	Authority.
		Ft. In.	Years.	In.		
Newbattle Abbey,	1789	10 4	...	...	...	Dr. Walker
The same tree, .	1892	18 1	103	93	0·90	D. Christison

Rate from known age of tree at 5 feet up.

Situation.	Last Observation.	Girth.	Period	Rate.	Authority.
		Ft. In.	Years.		
Sorn, Ayrshire, .	1881	11 4	156	0·87	Mr. Hutchison's Table
The same tree for same period at 1 foot, . .				0·93	...

VIII. The Horse Chestnut (*Æsculus hippocastanum*).

Great trees seem to be rarer in this than in any other of the deciduous forest species in Scotland. There are but three in Mr. Hutchison's table above 15 feet in girth at 5 feet from the ground; and although one reaches 19 feet, this may be not quite at the narrowest part, as the bole is only 8 feet high. The species seems not to have been introduced in Britain till about 1620, and may not yet have had time to produce giants.

Scottish horse chestnuts above 17 feet in girth at 5 feet up. From Mr. Hutchison's Table of 68 Scottish horse

chestnuts (Trans. H. and Agr. Soc. Scot. xvi., 1884, p. 192).

SITUATION.	Girth.		Height of Bole.		Height of Tree.	Spread of Branches.
	Ft.	In.	Ft.	In.	Ft.	Ft.
Eglinton Castle, Ayr, .	17	9	5	0	56	70
Moncrieffe, Perth, . .	19	0	8	0	80	...
Highest.						
Invercauld, Aberdeen, . .	8	7	6	6	110	55
Only three attain 90 feet or upwards.						
Greatest branch spread.						
Newbattle, Midlothian,	13	0	15	0	75	103

Number 15 feet in girth and upwards.

15 to 16 feet, ...	0
16 ,, 17 ,, ...	1
17 ,, 18 ,, ...	1
18 ,, 19 ,, ...	0
19 and upwards, ...	1
Above 15, . .	3
Above 20 at 1 foot up, ...	2

RATE OF GIRTH-INCREASE.

SITUATION.	Last Observation.	Girth.	Period.	Rate.	Authority.
From measurements at 5 feet up.					
		Ft. In.	Years.		
1. Edin. Arboretum, .	1892	1 1·25	5	1·15	D. Christison
2. Do. do. .	,,	1 2·15	1	1·35	Do.
3. Do. do. .	,,	0 11·10	1	1·15	Do.
4. Annat Lodge, Perth,	1889	3 3·00	1	1·05	Dr. Buchanan White
From measurements at 4 feet up.					
Polloc, Renfrew, .	1883	15 6·00	47	1·37	Mr Hutchison's Table

Rate from known age of the Tree, at 5 feet.

SITUATION.	Last Observation.	Girth.	Age.	Rate.	Authority.
		Ft. In.	Years.		
Yester, Haddington, .	1883	8 6	90	1·13	Mr. Hutchison's Table
At 4 feet.					
Bargaly, Kirkc'dbright	1780	6 10	83	1·00	Dr. Walker

From the scanty data I have to offer, the horse chestnut appears to be rather a quick grower, even at a considerable age.

IX. The Walnut (*Juglans regia*).

The walnut cannot be said to make itself much at home in Scotland, where it rarely, if ever, ripens its seed, but a few have been known to attain fair proportions, and the tree at Stobhall, 21 feet 2 inches in girth, 70 feet high, and with a branch spread of 99 feet, must be exceptionally fine.

Scottish walnuts above 15 feet in girth, at 5 feet, chiefly from Hutchison's Table of 40 Scottish walnuts. (Trans. H. and Agr. Soc. Scot. xvi., 1884, p. 196.)

Situation.	Girth.	Bole.	Height.	Spread of Branches.	Authority and Remarks.
	Ft. In.	Ft.	Ft.	Ft.	
Cawdor Castle, Nairn,	15 6	..	60	69	Mr. C. Clark, forester, 1891
Biel, East Lothian .	16 1	..	65	..	Dead in 1883
Castle-Huntly, Perth,	16 2	7	65	..	
Ballinshoe Castle, Forfar,	15 7	..	52	..	
Edmonstone, Midlothian,	15 11	..	..	..	At 1 ft. 3 in., the narrowest. Sir R. C., 1879
Stobhall, Perth,	21 2	12	70	99	..
Highest.					
Milne-Graden, Berwick,	13 9	25	80	..	..
Only two others reach 80 feet in height.					

Two walnuts, reputed to be the finest in Scotland, were blown down in 1882, at Otterstone, Fife. One is stated, in the information given to Mr. Hutchison, to have been 16 feet in girth at 12 feet, and the other 18 feet at 20 feet, but perhaps measurements taken at such unusual heights were intended to make the most of the girths, and were at the swelling below the great limbs, because I am informed by Mr. John Taylor, cabinetmaker, Edinburgh, who bought one of them, that its stem, 12 feet in length, averaged 4 feet 6 inches in diameter, giving a girth of about 14 feet. Mr. Taylor also tells me that, although the wood of Scottish walnuts is almost always soft and of little value for cabinetmaking, in this instance it was equal to the best Italian quality, and proved to be worth between £300 and £400 for veneering.

Walnut at Whitehall, Shrewsbury.—At 4 feet,

15 feet 7½ inches; spread of branches, 120 feet.—Journal of Forestry, v., 384.

HAWKSTONE PARK, SHROPSHIRE.—1000 feet above the sea; 22 feet in girth at 1 foot; 16 feet 6 inches at 5 feet; 99 feet high; circumference of foliage, 279 feet. —Mr. Hutchison.

Rate of girth-increase in walnut trees:—

Situation.	Last Observation.	Girth.	Period.	Rate.	Authority.
Rate in Trees of known age, at 4 feet up.					
		Ft. In.	Years.	In.	
Lochnell, Argyll, . .	1771	3 3	36	1·08	Dr. Walker
Kames, Bute, . . .	,,	6 1	70	1·04	do.
Kinross House, Kinross,	1796	9 6	112	1·01	do.
At 5 feet up.					
Logiealmond, Perth, .	...	8 1	110*	0·88	do.
Rate from girth measurements at 5 feet up.					
Gordon Castle, Banff, .	1883	13 4	45	1·02	Mr. Hutchison
Bradford, Wilts, . . .	1892	8 4	1	0·70	Dr. Beddoe

* Ascertained by counting rings in companions blown down.

The remaining deciduous species being less important, and my information concerning them being comparatively slight, I shall do little more than record the collected data.

X. THE POPLAR (*Populus*, species often not recorded).

Situation.	Girth at 1 Foot.	Girth at 3 Feet.	Girth at 4 Feet	Girth at 5 Feet.	Authority.
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	
Castle-Menzies, Perth, . .	..	..	..	11 6	Sir R. Menzies, 1892.
Holyrood Park, Edinburgh,	..	..	..	11 10	Sir R. Christison, 1878.
Bank of Tweed, Gattonside House, Melrose	14 6	13 0	12 9	12 4	D. C., 1892. Bole, 50 ft; Height, 100 ft.
Alloa House, Clackmannan,	..	..	13 6	..	Dr. Walker, 1792.
*Kelso, Roxburgh, . .	..	..	13 8	13 2	D. Christison, 1892.
Scone, Perth, . . .	18 4	15 7	..	14 9	A. M'Kinnon, 1893.
Brahan Castle, Ross, . .	17 4	15 4	..	15 0	Mr. W. H. Gunn, forester, 1889.
Methven Castle, Perth, .	..	16 9	16 4	16 1	Colonel Smythe, 1892.
Duncrub Park, Perth, . .	19 0	..	..	17 0†	Hon. B. Rollo, 1893.

* One of a group of a dozen, 80 to 100 feet high, at the junction of the Teviot and Tweed; two others girth 10 feet 10 inches and 10 feet 2 inches at 5 feet up.

† At 6 feet; a limb, 8 feet in girth, given off 18 inches from ground, prevents measurement at 5 feet. Height, 70 feet; branch spread, 100 feet.

Poplars grow to a great size in the English Midlands. Mr. Malcolm Dunn saw a black Italian poplar cut down in 1863 at Eardiston, Worcestershire, of which the quarter girth, 6 feet up, was 5 feet 3 inches. The lower cut of 12 feet contained 250 cubic feet of sound but coarse timber. Above that it branched. The tree as it stood sold for £10.

Rate of *P. nigra*, 16 feet 9 inches in girth, at 3 feet up, Methven, Perth, from records (Col. Smythe).

	Period.	Increase.	Rate.	Remarks.
	Years.	In.	In.	
1776 to 1812, . .	36	81	2·25	It may be remarked that the rate at 5 feet could not be much less than at 3 feet, as the stem was only 8 inches less at 5 feet than at 3 feet.
1812 ,, 1825, . .	13	31	2·38	
1825 ,, 1839, . .	14	32	2·28	
1839 ,, 1849, . .	10	15	1·50	
1849 ,, 1892, . .	43	42	0·90	
	116	201	1·73	

Nisbet, Berwickshire—Lombardy poplar, 60 ft. high; 6 ft. 1 in. in girth at 4 ft.; 26 years old; rate, 2·80 (Dr. Walker, 1795).
Craiglockhart, Edinburgh—Balsam poplar, 50 ft. high; 4 ft. in girth at 4 ft.; 27 years old; rate, 1·77 (Dr. Walker, 1795).
Annat Lodge, Perth—*P. balsamifera*, 4 ft. 5 in. in girth, rate 0·70; *P. fastigiata*, 7 in. in girth, rate 1·40; *P. alba*, 1 ft. in girth, rate 2·50, all at 5 ft. up, and for one year (Dr. Buchanan White).

XI. The Oriental Plane (*Platanus orientalis*).

As this species thrives well in the smoke of London, attempts have been made to introduce it in the Edinburgh gardens, but with little success. It grows fairly well for a time, but seems unable to withstand our strong winds. Last century, as we are told in Dr. Walker's essays, the oriental plane was introduced with some success in Rothesay. Lord Bute planted one at Mount Stuart in 1738, which in 1786 was 6 feet 10 inches in girth, giving an annual rate of 1·70 inch. Another at Kaimes was 60 feet high, with a clear stem of 15 feet, 4 feet 1 inch in girth. Dr. Walker also mentions one at Loudon Castle, 4 feet 5 inches in girth. All these girths are at 4 feet from the ground. I have not found any notices of oriental planes in Scotland at the present day.

LEE COURT, BLACKHEATH, KENT.—Girth of an oriental plane at 6 feet, 14 feet 8 inches. Height 60 feet (Strutt's Sylva Brit., 1822).

RILSTON PARK, YORKSHIRE.—The following dimensions furnished me by the Rev. J. J. D. Dent:—

Position.	Girth. Ft.	Girth. In.	Position.	Girth. Ft.	Girth. In.
At the ground, . .	18	0	At 3½ feet, . . .	14	0
,, 1 foot, . . .	16	4	,, 4 feet, . . .	13	7
,, 2 feet, . . .	15	7	,, 6 feet, . . .	14	0
Girth of an arm, . .	8	6	Length of an arm, .	34	0

The rate of a *Platanus* at the Chantry, Bradford-on-Avon, Wilts, 7 feet 10 inches in girth at 5 feet up, for two years, was 1·50 inch (Dr. Beddoe, 1892).

XII. THE BIRCH (*Betula alba*).

Professor Walker, 1790, quotes from the Stat. Hist. that "many birches in Darnaway Forest girthed 9 feet," and that a birch at Ballogie, Aberdeen, was judged to be 100 feet high.

"A large grove at Balmacniel, Perthshire, 4 to 5 feet in girth at 5 feet up, and 50 to 70 feet high" (Sir R. Christison, 1879).

Birches at "The Bog," Pityaulisk House, Strathspey.	Girth at The Root. Ft.	Girth at The Root. In.	Girth at 5 Feet up. Ft.	Girth at 5 Feet up. In.	Remarks.
No. 1, ...	8	2	6	8	Of good girth for 30 feet
No. 2, ...	6	10	6	10	Stem, 12 ft. Height, 60 ft.
No. 3, ...	7	7	7	3	About 50 feet high
No. 4, ...	...		7	10	(A. Clarke, forester, 1890)

From the above it does not appear that the birch often attains a great magnitude. Nevertheless, I have measured one at Newton Don, Roxburgh, girthing 13 feet ½ an inch at the narrowest part of the short stem, which forks at 30 inches above ground, one limb girthing 9 feet 2 inches, the other 7 feet 4½ inches at 5 feet up; height 80 feet; branch spread 70 feet (Sept. 1893).

In England, two at Moccas Park, Hereford, girth 10 feet 1 inch and 9 feet 2 inches at 5 feet up (Trans. Woolhope Club, 1870); and one at Holwood, Kent, 12 feet 2 inches at 3 feet, and 12 feet 1 inch at 5 feet; stem

short; the three limbs, 4 feet from the fork, girthed 5 feet 8 inches, 4 feet 1 inch, and 3 feet 7 inches; height, 62 feet; branch spread 57 feet (Mr. A. D. Webster, 1889).

In Ireland, one at Powerscourt, Wicklow, blown down 1868, girthed 12 feet 8 inches at 3 feet up, the narrowest; height, 75 feet (Mr. M. Dunn).

Rates from girth measurements at 5 feet up (D. Christison).

Situation.	Last Observation.	Girth.		Period.	Increase.	Rate.
		Ft.	In.	Years.	In.	In.
Craigiehall, West Lothian,	1890	6	1	11	4·80	0·43
Edinburgh Arboretum, .	1892	2	2·65	6	5·80	0·96
Do. do.	,,	1	3·90	6	6·60	1·10
Do. do.	,,	1	3	1	1·75	1·75

XIII. The Willow (*Salix*).

I have not seen any account of a large Scottish willow. A decaying short-stemmed one in the Edinburgh Botanic Garden measures 17 feet at the ground and at 1 foot above it, and 18 feet at 2 feet, where the branches are given off. The species grow to a great size in the English Midlands, but I have met with few records of the girths of great English willows.

Haversholme Priory.—Girth at 1 foot, 27 feet 4 inches; 4 feet, 20 feet 5 inches; 7 feet, 28 feet. Height, 40 feet.

Abbots Willow, Bury St. Edmunds.—Girth, 18 feet 6 inches, probably at narrowest; two limbs 15 feet and 12 feet. Height, 75 feet (Strutt).

Rates—1 and 3, Edinburgh Botanical Garden; 2, Annat Lodge, Perth.

	Last Observation.			Period.	Increase.	Rate.	Authority.
No.		Ft.	In.	Years.	In.	In.	
1. Salix, Sp., .	1892	0	8·45	3	5·85	1·95 at 5 ft.	D. Christison
2. S. Smithiana,	1889	2	7·30	1	3·05	3·05 at 5 ft.	Dr. Buchanan White
3. S. alba, . .	1798	9	4	33	112·00	3·39 at 4 ft.	Dr. Walker

XIV. The Alder (*Alnus glutinosa*).

"I had in 1760 a headed alder in my park at Hevingham, Norfolk, 16 feet $2\frac{1}{2}$ inches in girth at 4 feet up" (Mr. R. Marsham).

Mr. Edwin Lees gives a drawing of a monstrous hollow alder near Strawley, Worcester, 45 feet in girth at the base, the neck being 2 feet up, where from the drawing it must be 30 feet at least (Journal of Forestry, vi., p. 4). May this not be more than one tree?

Rate of girth-increase at 5 feet of an alder, Edinburgh Arboretum (D. Christison).

Last Observation.	Girth.	Period.	Rate.
	Ft. In.	Years.	Inch.
1889	1 0·35	3	0·95

XV. THE AUSTRALIAN GUM TREE (*Eucalyptus*).

Several species planted in the Isle of Arran by the Rev. D. Landsborough, Kilmarnock (information furnished by him). Girths at 5 feet up. In calculating the rates I have made allowance where necessary for growth to 5 feet. All the trees were sown or planted, and the measurements taken, in spring.

		Girth.	Height.		Annual Rate.	
					Girth.	Height.
		In.	Ft.	In.	In.	Ft. In.
*E. alpina.	Planted . 1884	...	2	0	...	...
	Dimensions 1892	8	13	1½	1·33	1 4
E. globulus.	Sown . 1874	...	...		...	...
	Dimensions 1887	24½	...		2·4	...
	Do. 1892	37	...		2·6	...
E. pauciflora.	Planted . 1880	...	A few inches.		...	...
	Dimensions 1887	9½	21	0	1·9	3 0
	Do. 1892	23	31	7	2·7	2 1
E. viminalis.	Sown . 1871	...	...		...	...
	Dimensions 1887	14½	28	0	1·2	1 9
	Do. 1892	25	43	9	2·1	3 1
E. urnigera.	Planted . 1887	...	3	0	...	..
	Dimensions 1892	6	16	0	1·5	2 9

* Has grown three times as rapidly as two of the same species in Melbourne Botanic Garden.

Eucalyptus, Sp.? Whittinghame, East Lothian (Mr. J. Garrett, head gardener). From seed about 1845. In 1861, when 40 feet high, injured by frost and cut over at 9 feet up. Stump apparently dead for nearly two years, but in 1863 it budded at the base and made a fresh start. Stem at 3 feet up divides into four branches.

Girths, April 1893 (branches taken at 5 feet above ground).

	Ft.	In.		Ft.	In.
Trunk at 2 feet, . .	11	10	Branch No. 3, . .	4	9
Do. 3 feet, . .	12	2	Do. No. 4, . .	3	8
Branch No. 1, . .	6	7	Height, . . .	62	0
Do. No. 2, . .	4	10			

The upward growth has been at the annual rate of about 2 feet for thirty years; and the girth-rate at 2 feet, probably the narrowest part, about $3\frac{1}{4}$ inches for forty-three years, a deduction of four years being made for growth to 2 feet, and for two years of inactivity, from 1861 to 1863.

XVI. Other Deciduous Species.

		Girth.	
		Ft. In.	
Carpinus Betula, .	Bargaly, Kirkcudbright	6 2 at 4 ft.	Dr. Walker, 1780
Do.	Writtle, Essex	12 0 ,, 5 ,,	Mr. R. Marsham, 1764
Cratægus Oxyacantha	Loch Leven, Kinross	6 4 ,, 5 ,,	Dr. Walker, 1796
* Do.	Castle-Huntly	6 10 ,, 8 ,,	do. do.
* Do.	Scone, Perth	9 0 ,, 4 ,,	do. do.
† Do.	Hethel Ch., Norfolk	9 $1\frac{1}{2}$,, 4 ,,	Mr. R. Marsham, 1755
‡ Do.	Holwood, Kent	14 6 ,, 3 ,,	Mr. Webster, 1889
Cytisus Laburnum, .	Greenlaw, Edinburgh	4 6 ,, 4 ,,	Dr. Walker, 1763
Prunus Padus, . .	Drumlanrig, Dumfries	8 0 ,, 4 ,,	do. do.
§ Prunus (Geen), . .	Holm, Kirkcudbright	5 6 ,, 4 ,,	do. do.
Do. (White Heart Cherry)	Kames, Bute	5 10 ,, 4 ,,	do. do.
Pyrus communis, .	Melrose	8 10 ,, 4 ,,	do. 1795
Do.	do.	8 0 ,, 4 ,,	Mr. Curle, 1893
Do.	do.	8 0 ,, 2 ,,	do. do.
Do.	Restalrig, Edinburgh	12 0 Stem $2\frac{1}{2}$ ft.	Dr. Walker, 1799
‖ Pyrus malus, . .	Jedburgh	7 2 at 3 ft.	do. 1763
Robinia pseudac, .	Newland, Gloucester	11 0 ,, 5 ,,	D. Christison, 1893
¶ Do.	Hollydale, Kent	14 10 ,, 3 ,,	Mr. Webster, 1889

* From the Stat. Account. † One arm extended 21 feet.
‡ Divides at 3 feet into six limbs, 4 feet 2 inches, 4 feet, 5 feet 8 inches, 2 feet 8 inches, 4 feet 4 inches, and 3 feet 5 inches in girth. Height, 42 feet; Branch spread, 63 feet.
§ Height, 50 feet; Branch spread, 33 feet. ‖ Branch spread, 40 feet.
¶ Height, 78 feet; Branch spread, 54 feet.

Quercus Cerris—Cramond House, Midlothian, 12 feet 8 inches at 5 feet (narrowest point)—(Sir R. C., 1878).
Quercus rubra—Newton Don, Berwick, 8 feet $3\frac{1}{2}$ inches at 3 feet (narrowest point). Circumference of foliage, 220 feet; longest branch, 41 feet (D. Christison, 1893).

		Last Observation.	Girth.	Period.	Rate at 5 Feet.	
			In.	Yrs.	Ins.	
Amygdalus communis	Bradford-on-Avon	1892	20	1	0·90	Dr. Beddoe
Carpinus Betula .	Edin. Arboretum	,,	12	6	0·79	D. Christison
Cratægus Oxyacantha	do.	,,	16	5	1·15	do.
Do.	Edin. Botanical Gar.	,,	46	15	0·55	do.
Cytisus Laburnum .	Edin. Arboretum	,,	11	6	0·80	do.
Mespilus germanica,	Bradford-on-Avon	,,	14	1	0·85	Dr. Beddoe
Morus nigra, . .	Clifton, Bristol	1891	9	4	0·90	do.
Prunus Padus, . .	Drumlanrig, Dumf.	1773	96	70	1·37	Dr. Walker
Do.	Edin. Arboretum	1892	13	5	1·28	D. Christison
Do.	do.	,,	14	1	2·00	do.
Pyrus Aucuparia, .	do.	,,	15	5	0·94	do.
Do. communis, .	do.	,,	12	1	0·95	do.
Do. do. .	Clifton, Bristol	1891	24	2	0·87	Dr. Beddoe
Quercus Cerris, .	Edin. Botanical Gar.	1892	50	15	0·56	D. Christison.
Do. do. .	do.	,,	64	6	0·60	do.
Do. do. .	Craigiehall, W. Loth.	1890	82	11	0·89	do.
Do. conferta, .	Edin. Botanical Gar.	1892	34	13	1·54	do.
Do. do. .	do.	,,	38	13	1·68	do.
Do. do. .	do.	,,	47	15	1·54	do.
Do. rubra, . .	do.	,,	9	3	1·06	do.

B. NON-CONIFEROUS EVERGREENS.

I. THE HOLLY (*Ilex aquifolium*).

Many hollies branch near the ground, when measurement at 5 ft. is impracticable. But some have an appreciable bole, and enter the class of smaller forest trees. Only nine in Mr. Hutchison's list attain 45 ft. in height, the highest being 52 ft.; and only three attain 10 ft. in girth at their narrowest, the biggest being 12 ft. 6 in. But a holly at Clochfaen, Llanidloes, N. Wales, girths 30 ft. above the roots; two of its sixteen main branches, which spring from near the ground, girth 11 ft. 7 in. and 8 ft. 2 in.; height, 43 ft.; branch spread, 54 ft. Another holly in the same valley girths 17 ft. 6 in. at the ground (Col. G. H. Lloyd-Verney, 1893).

Hollies above 7 ft. in girth. From Mr. Hutchison's Table of 89 Scottish hollies (Trans. H. and Agr. Soc. of Scot., 1892).

Hollies with short boles.				
SITUATION.	Bole.	Girth at 1 Foot.		Height.
	Feet.	Ft.	In.	Feet.
Darnaway, Moray, ...	3	9	0	40
Do. do.	3	8	8	30
Do. do.	2	10	4	38
Do. do.	3	7	10	35
Do. do.	3	12	6	30
Do. do.	3	10	8	35

Hollies with comparatively long boles.

Situation.	Bole.		Girth at 1 Foot.		Girth at 3 Feet.		Girth at 5 Feet.		Height.
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Feet.
Skibo, Sutherland, .	7	9	7	3	6	8	...		28
Do. do. .	8	0	7	0	6	6	...		42
Kinloch, Meigle, Perth, .	15	0	7	2	..		7	3	40
Gordon Castle, Moray, .	7	0	...		8	5	7	7	33
Darnaway, Moray, .	15	0	9	9	...		9	4	42
Glenkill, Arran, . .	14	0	...		8	3	...		50
Do. do. . .	18	0	11	2	9	2	8	1	33
Hollydale, Kent (A. D. Webster), . . .	...		...		9	4	9	2	...

Rate of Girth-Increase.

The only apparently reliable rate of girth-increase in the holly that I can find is given below. If the reputed age of other trees in Mr. Hutchison's list were reliable, they would yield a much slower rate, but the one I give is the only instance in which the date of planting is positively stated.

Situation.	Length of Bole.	Girth at 5 feet.		Age.	Rate.
	Feet.	Ft.	In.	Years.	Inch.
Brahan, Ross, ...	12	6	10	112	0·74

II. The Evergreen Oak (*Quercus Ilex*).

One at Castle-Kennedy, Wigtownshire, girths 15 feet at 1 foot; 14 feet at 3 feet; 15 feet at 5 feet; is 48 feet high, and the circumference of foliage is 186 feet (Mr. W. Cruden, gardener, 1893).

Another at Burghill, Hereford, girthed 9 feet 10 inches at 5 feet, was 50 feet high, and had a branch spread of 63 feet (Trans. Woolhope Club, 1870).

Rate of an evergreen oak, Edinburgh Botanical Garden, injured by severe winter of 1878,—46·60 inches in girth

in 1892; also of a very young one, Edinburgh Arboretum, 8 inches in girth 15 inches up.

	Period.	Increase.	Rate.
	Years.	Inches.	
1879 to 1889, old tree	11	3·40	0·31
1889 to 1892, old tree	3	1·70	0·56
1887 to 1892, young tree	6	3·70	0·62

III. THE BOX (*Buxus sempervirens*).

Dimensions of box trees on Inchmahome, Lake of Menteith (Mr. R. Hutchison, 1887).

	Girth at Ground.		At 1 foot.		Height.	
	Ft.	In.	Ft.	In.	Ft.	In.
Largest, . . .	2	8	3	3	20	6
Other two, . . .	1	3	...		22	0

C. CONIFERÆ.

1. NATIVE OR LONG-INTRODUCED.

I. THE SCOTS FIR (*Pinus sylvestris*).

I have been able to hear of but few existing native firs of remarkable size in Scotland. Indeed, the general impression as to the dimensions attainable by the species may be expressed by the bold assertion, made a few years ago, that a Scots fir blown down at Lawers, measuring only 13 feet 9 inches in girth, was the largest in the world! Nevertheless, besides three trees of slightly greater girth,—one of 14 feet 7 inches, "Magog," at Guisachan; another of 14 feet in Duthil Forest; the third, "Peter Porter," 13 feet 10·5 inches (Sir R. Christison, 1880), at Abernethy,—there are two which exceed the Lawers tree by several feet, one at Glenfeshie, 15 feet 8 inches at 5 feet, the other at

Abernethy, no less than 1500 feet above the sea, 16 feet 6 inches at 3 feet, the narrowest point. That other giants do not exist is no doubt due to the almost total destruction of the primeval Highland forests about a century ago, when they were leased to English companies for shipbuilding or manufacturing purposes. Certain it is that even greater dimensions were attained by at least one tree in Glenmore, a plank from which is preserved at Fochabers. By examination of this plank Sir Robert Christison proved (Trans. Ed. Bot. Soc., 1878, p. 229) that the tree from which it came must have been at least 19, and probably was 20 feet in girth at 6½ feet up. Mr. Clark, the forester, has informed me that the girth at its root, which existed in 1890, was 28 feet, and at a "middle cut," which still lay on the ground, was nearly 12 feet. Another tree in Glenmore Forest, possibly rivalling this, was blown down in 1868, which yielded a plank "certainly over 5 feet 6 inches in width."

This species is not remarkable for height in the Highland forests. A tree at Castle-Grant, blown down in 1868, called "The King" from its superior height, measured 93 feet, but it was only 6 feet in girth at the root. Only one other Highland tree in my table reaches 90 feet, and the next highest is only 70 feet. Probably the three magnificent trees at Arniston (see the Table) are unequalled in Scotland for combined height and girth. They rival neighbouring beeches, some of which were blown down, and measured on the ground considerably above 100 ft. Mr. J. S. Blackett, C.E., measured one 7½ feet in girth, at Bessborough, Co. Kilkenny, as it lay on the ground, which was 97 feet long. —Mr. J. Horn Stevenson to Sir R. Christison, 1879.

In the plantations of North Germany the Scots fir is made to grow to a great height. According to Schwappach (Wachstum normaler Kiefernbestande, Berlin, 1889), at 140 years of age, 137 trees on an English acre should average 106 feet in height, with a girth about 4½ feet at breast height.—A. C. Forbes, in Trans. Roy. Scot. Arb. Soc., vol. xiii., p. 2.

Scots firs above 10 feet in girth at 5 feet up, unless otherwise stated.

Locality.	Girth. Ft. In.	Bole. Ft.	Height. Ft.	Authorities and Remarks.
Cammo, Midlothian,	10 2	23	71	Branch spread, 65 feet (Sir R. Christison, 1879).
Hopetoun, W. Lothian,	10 4	..	83	Mr. T. Smith, gardener, 1893.
Dunmore, Stirling,	*10 3	..	67	
Murthly, Perth,	10 7	..	..	Largest on estate, 1879.
Rossdhu, Dumbarton,	11 0	..	65	Conifer Conf. Statistics, 1891.
Bowhill, Selkirk,	11 0	25	55	13 feet 6 inches at ground; circumf. of foliage, 190 feet (D. C., 1893).
Dalswinton, Dumfries,	†11 3	4	..	
Taymouth Castle, Perth,	11 6	..	..	Sir R. Christison, 1878.
Brodie, Nairn,	‡13 0	..	60	
Castle-Huntly, Perth,	§13 6	..	..	
Lawers, Perth,	13 6	..	..	Journ. of Forestry, vi., 638.
Guisachan, Inverness,	‖14 7	..	...	
Moccas Park, Hereford,	10 11	..	..	Largest in Park (Trans. Woolhope Club, 1870).
In the Forests of Strathspey, Inverness.				
Loch an Eilan,	10 7	..	45	Mr. J. Christison, 1890.
The Slughan, Glenmore,	10 11	..	45	do. do.
Carr Bridge,	11 7	..	..	do. do.
The Slughan, Glenmore,	11 9½	10	50	do. do.
Gorge near Loch Morlich,	12 0	..	45	do. do.
Do. do.	12 1	27	..	14 feet 2 inches at ground (Mr. Clarke, forester, 1890).
Loch an Eilan,	12 3	50	70	Branch spread, 60 ft. (J. C., 1890)
Ord Bain, Loch an Eilan,	13 1	..	50	J. Christison, 1890.
Abernethy,	13 10·5	..	..	"Peter Porter" (Sir R. C., 1880)
Sleuich, do.	16 6	10	52	At 3 ft., 16 ft. 6 in., also at the ground, 18 ft. at 4 ft., 18 ft. 5 in. at 5 ft. (Mr. J. G. Thomson, wood manager, May 1893)
Lethendry Hill, Duthill For.,	10 0	21	65	Great head of foliage (Mr. Mackinnon, forester, 1890).
Do. do.	10 2	..	..	120 cubic feet of timber do.
Do. do.	10 9	10	..	Three limbs at 10 feet do.
Do. do.	10 9	24	..	Massive spreading top do.
Do. do.	11 5	40	..	do. do.
Do. do.	12 6	6	..	Divides into two at 6 feet do.
Do. do.	14 0	10	90	Divides into two at 10 feet do.
Glenfeshie Lodge, Kingussie,	15 8	10	60	20 feet at the ground (Mr. James Bell, gardener, 1892).
Castle-Grant,	10 5	..	..	Mr. Stuart, forester, May 1893.
Do.	10 6	..	..	do. do.
Do.	10 6	..	..	do. do.
Do.	10 10	..	..	do. do.
Scots firs remarkable for height.				
Castle-Grant, Strathspey,	6 0	..	93	"The King," blown down 1868 (Mr. J. G. Thomson).
Arniston, Midlothian,	9 11	50	110	Stand well apart, have fine symmetrical boles and good heads. Height measured by two methods (Mr. Cook, factor, and D. Christison, June 1893).
Do. do.	9 8	50	..	
Do. do.	8 3	50	..	

* At 17 feet up; 11 feet 3 inches at ground. "Perhaps the largest in South Scotland" (Strutt, 1825).

† At 3 feet, the narrowest; foliage abundant and healthy (April 1893, D. Christison).

‡ At 4 feet; branch spread, 85 feet (Journ. of Forestry, 1892).

§ At 3 feet; 19 feet at ground; "probably the largest planted fir in the country" (Dr. Walker, 1796).

‖ At 6 feet; 16 feet at ground; 14 feet 9 inches at 3 feet; 15 feet 3 inches at 9 feet; 16 feet 8 inches at 12 feet; 17 feet at 15 feet. Cubic contents of the 15 feet, 210 feet (Mr. Harvie Brown, Annals of Scot. Nat. Hist., 1892).

RATES OF GIRTH-INCREASE.

(*a*) Ascertained by counting rings (Sir R. Christison).

LOCALITY.	Girth.		Age.	Rate.	Remarks.
	Ft.	In.	Yrs.		
Glenmore Forest, Morayshire, . .	19	0	272	0·84 at 6 ft. 6 in.	Plank at Fochabers.
	8	8	166	0·68 at 3 ft.	Section of stem.

(*b*) Rate in a grove at Rothiemurchus, estimated by counting rings in a felled tree, the others, which are standing and which girth from 8 to 12 feet, believed to be of the same age (Rev. Mr. M'Dougall).

	Date.	Girth at 5 feet.	Age.	Rate.
	Year.	Feet.	Years.	Inches.
Smallest tree, . . .	1890	8	150	0·64
Largest, ...	,,	12	,,	0·96
Average, . . .	,,	10	,,	0·80

(*c*) Ascertained by girth measurements at $2\frac{1}{2}$ ft., the narrowest (Sir R. Christison, Mr. W. M. Leny, and D. Christison).

LOCALITY.	Date.	Girth.		Period.	Rate.
	Year.	Ft.	In.	Years.	Inches.
Dalswinton, Dumfries, .	1855	9	1	...	...
Do. do. .	1875	10	8	20	0·95
Do. do. .	1892	11	3	17	0·41

Although the rate, on the whole, is apparently decreasing in the last period of seventeen years, it rose to 0·80 in the final five years, and the tree is in splendid condition.

(*d*) Five young trees planted at Dalswinton in precisely the same circumstances as the larches (see under Larch), varied in girth at 5 feet from $11\frac{9}{10}$ inches to $12\frac{7}{10}$ inches in April 1893, and their rate for eight years was between 1·52 and 1·58.

(*e*) Ascertained in trees of known age (Conifer Conf. Statistics, 1891).

LOCALITY.	Height.	Age.	Girth.		Rate.
	Feet.	Years.	Ft.	In.	Inch.
Hewell Grange, Worcester, .	90	75	9	6	1·52
Curraghmore, Waterford, .	90	120	6	6	0·65
Scone, Perth, . . .	48	41	3	8	1·02

(*f*) Many in the Posso plantation, Tweeddale, planted 1740, girthed 4 feet at 4 feet up, in 1767; rate, 1·77 for twenty-seven years. A Scots fir at Bargaly, Kirkcudbright, eighty-three years old, girthed 9 feet 3 inches at 4 feet; rate, 1·33, and was 90 feet high (Dr. Walker).

The possible rate of girth-increase in Scots firs of great size in the primeval forests is established by the fortunate preservation of the plank at Fochabers, by counting the rings on which Sir R. Christison clearly proved that a tree measuring probably 20, but certainly 19 feet in girth 6½ feet above ground, may attain that vast bulk in 272 years, or at the rate of 0·84 inch annually. He also found that although the rate varied in different decades, it was not much, if at all, less towards the end than at the beginning of the tree's career. This he attributed to the unusual height of the conoid base, but it is not likely that this influence could be great so high as 6½ feet, and possibly equality of the rings throughout life may be a true characteristic of this and other species in exceptionally vigorous specimens.

The Dalswinton tree (*c*) confirms Sir R. Christison's observation of the variation in rate in different decades in the Fochabers plank, as it grew very slowly from 1875 to 1888, and much more quickly from 1888 to 1893. The great rate of the Hewell Grange tree (*e*), 1·52, is confirmed by Dr. Walker's examples (*f*), and the five young Dalswinton ones (*d*).

ii. The Yew (*Taxus baccata*).

The general rule of measuring at 5 feet from the ground is inapplicable to this species, because of its various habits of growth. Some aged yews are buttressed like other large trees, but this is exceptional. Others are cylindrical from the ground, and change but little in girth till the branches are given off; in most of this class the stem is short, but in rare instances, unknown I believe in Scotland, it is long, like that of a pine tree. But frequently, in aged yews, the stem is narrowest at the ground, and swells rapidly to the offshoot of the branches, only a few feet from the ground. Hence, for comparison by a single

measurement, it is necessary to choose the narrowest point, although to give any true idea of size it is necessary to give several particulars.

Scottish Yews.—A catalogue of existing Scottish yews serves but to show their great inferiority to the celebrated Fortingall tree, reputed to be 54 feet in girth, of which mere fragments remain. The largest recorded survivor—at Craigends, Renfrew—is only 21 feet in girth, and probably no other exceeds 14½ feet at the narrowest point. Very few attain a great height. A yew at Bute stands clearly at the head with 64 feet, and only two others exceed 50 feet.

Yews above 13 feet in girth, probably at the narrowest part of the stem. From Mr. Hutchison's Table of 107 Scottish yews (Trans. Roy. Scot. Arb. Soc., 1890).

Locality.	Girth at 1 Foot.		Girth at 3 Feet.		Bole.		Branch Spread.
	Ft.	In.	Ft.	In.	Ft.	In.	Feet.
Pitmedden, Aberdeen, .	13	9	13	0	...		45
Loudoun Castle, Ayr, .	13	8	13	10	6	0	74
Pitmedden, Aberdeen, .	14	6	14	0	...		51
Lawers, Perth, . .	14	4	...		none		60
Parkhill, Perth, . .	14	5	15	0	7	0	...
Ormiston, East Lothian,	13	10	15	0	10	0	72
Craigends, Renfrew, .	21	0	...		1	6	80
Rossdhu, Dumbarton, .	13	3	12	8	...		...
Inch Lonaig, do. .	...		13	0	10	0	...

A remarkably fine thriving yew at Arngomery, Kippen, Stirling, measured by Mr. Malcolm Dunn, 1893, was 16 feet 2 inches in girth at the ground; 13 feet at 1 foot; 11 feet 1 inch at 5 feet; 11 feet 8 inches at 7 feet; circumference of branches, 220 feet; height, 38 feet. Height of clean stem, 8 feet; of bole, 15 feet.

A decaying yew on Glenmorriston Estate, four miles east of Fort-Augustus, roughly measured by Mr. Ewan Cameron, Glenlea, was 14 ft. in girth at 2 ft. up, and 80 paces in circumference of foliage (D. Brown Anderson, W.S., 1893).

English Yews.—If Evelyn is to be trusted, the largest-girthed British yew, or tree of any kind, of which we have any record, existed in his day, 1665, at Brabourne, Kent, as a ruin with a trunk 60 feet in girth. Not a vestige of it remains.

Four of the largest existing yews in England were measured expressly for Sir R. Christison, and I therefore give the results in full:—

SITUATION.	Girth.	Ft.	In.	Measurer.
Darleydale, Derbyshire, .	At the ground,	32	0	Mr. Smith, Nurseryman, of the Dale.
	,, 4 feet up, .	34	6	
Ankerwyke, Buckingham,	,, the ground,	25	0	Mr. Troy, Gardener to Mr. Anderson, Ankerwyke Ho.
	,, 3 feet up, .	30	5	
	,, 7 feet up, .	35	0	
Gresford, Wrexham, .	,, the ground,	22	4	Mr. Francis Manisty, Surgeon.
	,, 2 feet up, .	24	9	
	,, 4 ft. 5 in. up,	28	2	
	,, 5 ft. 4 in. up,	30	5	
Yewdale, Westmoreland,	,, 3 ft. (narr'w'st)	26	2	Bole 25 feet, J. Christison.

FOUNTAINS ABBEY YEW.—Burton, quoted by Strutt, describes a remarkable group of seven yews "growing on the declivity of the hill on the south side of the Abbey, all standing except the largest, which was blown down about the middle of last century. The trunk of one of them is 26 feet 6 inches in girth at 3 feet from the ground, and they stand so near each other as to form a cover almost equal to a thatched roof." Strutt then describes the wanton destruction going on in 1822, but his plate (No. XXI.) shows five still standing within a few yards of each other.

Only one now exists, and the stem is a mere shell, a third part of which at the bottom has decayed away, so that the tree would collapse but for artificial props. The head of foliage, however, is large and luxuriant. It is not the largest of the seven mentioned by Burton, as according to measurements made by the Rev. Mr. Bittleston of South Stainley in 1880, it was only 18 feet 6 inches in girth at 3 feet 6 inches up, instead of 26 feet. At 7 feet up, where there is an evident great expansion to the branches, it was 25 feet 3 inches.

This tree is interesting in its decay, because it serves to clear away doubts, which have very naturally arisen from the present condition of the remains of the Fortingall yew, as to their ever having been parts of one and the same tree. I found in 1887 in the Fountains Abbey yew that the wood springing from the earth was reduced to a

slender pillar in the centre, and a larger mass attached to the shell on one side. Nine-tenths of the circumference was a mere shell, a few inches thick, of which only two-thirds touched the ground; and it was evident that a little further decay would produce a ground plan very like that of the Fortingall remains (see Plate XII., Trans. Bot. Soc. Edin., vol. xiii.), and quite as difficult to reconcile with the supposition of original unity of the detached fragments.

YEWS IN PORTBURY CHURCHYARD, NEAR BRISTOL.—These are two fine examples of the rare variety, with tall stems, which at a distance resemble the Scots fir. About twenty years ago I found the one to be 15 and the other 17 feet in girth at 5 feet up.

RATES—TREES OF KNOWN AGE.

(*a*) West Felton, Shropshire.

Observation.	Period.	Increase.	Rate.	Observers.
	Years.	In.	In.	
1836	70	61	0·87	Mr. Bowman.
1878	42	33	0·78	Mr. Dovaston.
	112	94	0·84	

(*b*) Dalkeith, Midlothian, at 5 feet up.

1891	150	116	0·77	Mr. Malcolm Dunn.

(*c*) Average of eighteen yews at Gresford Churchyard, Wrexham, 120 years old (Parish Records, Bowman); girth, 5 feet 3 inches; rate, 0·52.

(*d*) Two yews, Edin. Bot. Garden (Dr. Christison).

	Last Observation.	Period.	Girth.	Increase.	Rate.
		Years.	Ft. In.	In.	
No. 1, . .	1892	15	6 2·70	7·10	0·47
No. 2, . .	,,	14	3 8·10	6·60	0·47

(*e*) Yew at Ormiston, East Lothian (1834, Sir T. Dick Lauder; 1879, Professor Balfour).

Date.	Girth at Ground.		Girth at 3 Feet.		Girth at 4 Feet.		Girth at 5 Feet.	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
1834, ...	12	9·00	13	6·00	14	9·00	17	8·00
1879, ...	13	10·00	15	0·00	16	10·00	19	8·00
Increase, 45 years,	1	1·00	1	6·00	2	1·00	2	0·00
Rate, . . .	0	0·28	0	0·40	0	0·55	0	0·53

Dr. Walker gives the girth at 4 feet as 10 feet 3 inches in 1762, making an increase to 1879 of 75 inches, and a rate of 0·74 for 117 years.

The estimation of the age of gigantic yews presents peculiar difficulties. No opportunity of counting their rings throughout can be expected, as not only is their little chance of such veterans being cut down, but the chance is equally small of finding the mass of the interior preserved from decay. To ascertain their present rate by girth measurement, at least within a moderate period of years, is scarcely possible, from the extreme irregularity of the surface, particularly at the usual narrowest point, near the ground. We are reduced, therefore, to such information as can be got from young trees, supplemented by borings at the surface of aged specimens. From the few reliable data collected by Sir R. Christison, he drew up the following scale of probable age for a yew 22 feet in girth.

Age.	Rate.	Girth.
	In.	In.
To 100 years, . .	About 0·50	54
,, 200 ,, . .	,, 0·40	96
,, 500 ,, . .	,, 0·24	168
,, 1000 ,, . .	,, 0·19	264

This estimate, however, is founded on the supposition that the giants grow only at the average ascertained rate in early life, and fall off gradually from an early period to the very slow rate, ascertained by Mr. Bowman's borings, of from 140 to 180 years for the last 18 inches of girth-increase in two yews 22 and 27 feet in girth. But two

elements of doubt remain. I have shown, in the first place, that the giants of other species probably grow at a quite exceptionally rapid rate, and that this is possible in the yew also is indicated by the exceptional rate of 0·84 for the first 112 years of life in one recorded by Mr. Bowman. Secondly, from Sir R. Christison's own observations on the large Craigiehall beech and the Fochabers Scots fir, it is plain that the falling off in rate, which in average trees begins before they have attained a large size, in trees destined to be great may be put off till they have assumed almost gigantic proportions. Hence, it is quite possible that Sir R. Christison's estimate of 1000 years for a tree 22 feet in girth may be several centuries in excess of the truth. The question might be solved by using the modern instruments which extract cylinders to a considerable depth, whereas Mr. Bowman's primitive borer only probed to a depth of a few inches.

Sir Robert's estimate of 3000 years for the age of the Fortingall yew may in a corresponding way be liable to great reduction.

Finally, it may be a question whether gigantic stems like these may not be compound—formed by the coalescence of two or more which were originally separate.

III. The Cedar (*Cedrus Libani*).

As the cedar somewhat resembles the yew in the varieties of form in the stem, I have given the girth at several points, so as to give a better idea of the true size of the specimens recorded.

Scottish cedars above 17 feet in girth at different heights, from Mr. Hutchison's Table of 58 Scottish cedars (Trans. H. and Ag. Soc. Scot., 1890).

Locality.	Girth at 1 Foot.		Girth at 3 Feet.		Girth at 5 Feet.		Bole.		Height.	Branch Spread.	Cubic Feet.
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Feet.	Feet.	
Gray House, Forfar, . .	..		17	0	..		19	6	55	..	323
Biel, East Lothian, . .	17	4	..		18	10	10	0	83	..	..
Beaufort Castle, Inverness,	19	9	..		21	0	4	6	80	70	..
Prestonhall, Midlothian, .	21	0	..		20	2	28	0	60	90	..
*Hopetoun, West Lothian, .	..		..		23	0	33	0	88	..	..

* Blown or cut down in a dying state lately.

60 to 70 feet in height, ... 14
70 ,, 80 ,, ... 4
80 ,, 88 ,, ... 5

It is remarkable that in Mr. Hutchison's list there are no cedars between 15 and 17 feet, so that the next largest to the five in my selection is at least 2 feet less than the least of them. He has missed, however, a very fine healthy tree at Arniston, Midlothian, which in 1893 I found to be 16 ft. 8 in. in girth at 5 feet, about the narrowest part of a symmetrical ten-foot stem.

The finest cedar in England in Loudoun's time was at Syon. He gives the height as 92 feet, the girth at 3 feet up as 24 feet, and the diameter of the branch spread as 117 feet. The tallest, 108 feet, appears to be at Strathfieldsaye, but its girth is only 9 feet.

Rates from Trees of known Age.

Situation.	Age	Girth in 1888 at			Rate at			Authority.
		1 Ft.	3 Ft.	5 Ft.	1 Ft.	3 Ft.	5 Ft.	
	Yrs.	Ft. In.	Ft. In.	Ft. In.	In.	In.	In.	
Biel, East Lothian, .	181	17 4	..	18 10	1·15	..	1·26	Mr. Hutchison's List
Dalkeith, Midlothian,	110	..	..	13 2	..	..	1·43	Mr. Mal. Dunn, 1891
Brahan, Ross, . .	80	9 1	8 3	7 10	1·36	1·23	1·17	Mr. Hutchison's List
Do. do. . .	150	12 6	11 9	11 7	1·50	0·93	0·92	do.
Tarbat, Ross, . .	62	..	7 2	..	..	1·39	..	do.
Beaufort, Inverness, .	150	19 9	..	..	1·58	..	..	do.
Rossie Priory, Perth, .	100	..	..	8 11	..	..	1·07	do.
Do. do. .	,,	..	..	8 2	..	..	0·98	do.
Do. do. .	,,	..	..	8 3½	..	..	0·99	do.
Dryburgh, Berwick, .	,,	10 4	9 7	9 3	1·24	1·15	1·11	do.
Drummond Cas., Perth,	63	..	..	7 9	..	..	1·47	do.
Do. do.	,,	..	.	8 2	..	..	1·55	do.

Great cedar formerly at Hopetoun, West Lothian, 23 feet girth at 5 feet.

Date.	Period.	Growth.	Rate.
	Years.	Inches.	Inch.
1740 to 1801, . .	61	120	2·00
1802 to 1841, . .	40	78	1·95
1842 to 1884, . .	43	78	1·81
	144	276	1·91

English cedar, West Felton, Salop (Mr. J. Dovaston).

Date.	Period.	Increase.	Rate.
	Years.	Inches.	Inch.
1773 to 1836, . .	63	99	1·58
1836 to 1880, . .	44	54	1·21
	107	153	1·43

English and Irish cedars (Conifer Conf. Statistics, 1891).

Locality.	Height.	Age.	Girth.		Rate.
	Feet.	Years.	Ft.	In.	
Bretby Park, Derby, . . .	82	215	16	2	0·90 at 5 feet
Hewell Grange, Worcester, . .	50	100	16	0	1·92 ,,
Howick Hall, Northumberland, .	51	70	12	0	2·05 at 2 feet
Revesby Abbey, Lincoln, . .	45	43	9	6	2·65 at 5 feet
Woodstock, Kilkenny, . .	78	66	9	2	1·27 ,,
Average of 140, Dropmore, Bucks,	65	80	7	6	1·12 at 3 feet
Largest at do. do.	104	100	13	9	1·73 ,,

Rate from Girth Measurements.

Locality.	Last Observation.	Girth at 5 Feet.		Period.	Rate.
		Ft.	In.	Years.	Inch.
Abercairney, Perth, .	1888	8	11	28	1·85
Annat Lodge, Perth, .	1889	11	8	1	1·60

Cedrus atlantica.

Rate in Trees of known Age.

Locality.	Age.	Height.	Girth at 5 Feet.		Rate.	Authorities and Remarks.
	Yrs.	Ft.	Ft.	In.	In.	
Biel, Haddington,	181	80	14	5	0·95	At 5 ft. (Mr. Hutchison's List).
Dropmore, Bucks,	49	64	5	10	1·42	At 3 ft. (Mr. Herrin, gardener, 1891).

Tree 4 feet in girth at 5 feet up, Botanic Garden, Edinburgh (D. Christison).

	Period.	Increase.	Rate.
	Years.	In.	In.
1878 to 1887, . . .	10	14·95	1·50
1888 to 1892, . .	5	6·20	1·24
Average, .	15	21·15	1·41

Cedrus deodara, Dropmore, Bucks (Mr. Ch. Herrin, gardener, 1891).

	Age.	Height.	Girth.		Rate.	Remarks.
	Yrs.	Ft.	Ft.	In.	In.	
No. 1, ...	51	72	9	9	2·30	At 3 feet up.
,, 2, ...	51	67	8	3	1·94	do.
,, 3, lightning-struck, .	50	...	12	3	2·94	Near the ground.

It is evident that the cedar of Lebanon, and its near relatives the Atlantic cedar and deodar, are quick growers, in favourable circumstances, in this country. There can be little doubt that the great cedar at Hopetoun, which attained 23 feet in girth, increased at the rate of nearly 2 inches annually throughout its life, and although this is probably exceptional, yet there are authentic instances of a similar or even greater rate in cedars of considerable size. The deodars at Dropmore attained the considerable rates, at 3 ft. up, of 1·94 and 2·30 for fifty years.

IV. THE SILVER FIR (*Abies pectinata*).

The silver fir has grown to a greater girth and height than any other pine in Scotland, where Mr. Hutchison states it was introduced about 1600. It appears to have been known in England, however, prior to 1548.

Silver firs above 17 feet in girth at 5 feet up. Chiefly from Mr. Hutchison's Table of 147 Scottish silver firs (Trans. H. and Agr. Soc. Scot., xviii., 1885, p. 240).

LOCALITY.	Girth at 5 Feet.		Girth at 3 Feet.		Girth at 1 Foot.		Bole.	Height.
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	Ft.
Drummond Castle, Perth,	17	5	...		22	10	32	106
Castle-Menzies, Perth, .	17	7	18	3	20	2	22	120
*Rossdhu, Dumbarton, .	17	9	...		...		...	110
Drummond Castle, Perth,	18	2	...		23	9	28	105
Roseneath, Dumbarton, .	21	8	22	8	28	0	90	125
Do. do. .	22	0	23	4	28	10	90	130
Tree with greatest branch spread (65 feet).								
Drumlanrig, Dumfries, .	13	8	...		20	6	59	96

* Mr. F. Macpherson, gardener, Conifer Conference Statistics, 1891.

There is a remarkable group of twenty-two silver firs near Inverawe, Argyll. Of eleven still standing, one is 17 feet in girth, another 15 feet 9 inches, another 14 feet 5 inches, and four more are above 12 feet. Of the fallen trees, one is 16 feet 1 inch, another 15 feet 4 inches, and three others are above 12 feet in girth, all at 5 feet above the highest part of the ground (Dr. Allan Macnaughton, 1893).

Number above 15 feet in girth at 5 feet up.

15 to 16 feet,	7
16 ,, 17 ,,	4
17 ,, 18 ,,	4
18 ,, 19 ,,	1
19 ,, 20 ,,	0
Above 20 ,,	2
Above 15 feet,	18

Number 100 feet high,	10
,, 100 to 109 feet high,	20
,, 110 ,, 119 ,,	18
,, 120 ,, 129 ,,	9
,, 130 feet high,	2
100 feet high and upwards,	59

A few other remarkable silver firs.

Locality.	Girth at 5 Feet.		Authorities and Remarks.
	Ft.	In.	
Lynedoch, Perth,	13	8	104 feet high (Mr. L. Bayne, forester, Conifer Conf. Stat., 1891).
Castle-Menzies, Perth,	14	6	Sir Robert Menzies, 1892.
Arniston, Midlothian,	14	0	About 100 ft. high (D. Christison, 1893).
Dunkeld, Perth,	14	6	110 feet high (Sir R. Christison, 1879).
Do. do.	...		120 feet high do.

(*a*) Rate of Girth-increase in Trees of known Age, at 5 Feet.

Locality.	Date of Observation.	Girth.		Age.	Rate.	Authority.
		Ft.	In.	Years.	In.	
Craighall, Perth,	1884	10	3	89	1·38	Mr. Hutchison's List.
Drumlanrig, Dumfries,	,,	11	1	70	1·90	Do.
Do. do.	,,	11	10	70	2·03	Do.
Rossdhu, Dumbarton,	1891	17	9	108	1·93	Mr. F. Macpherson, gardener.
Dalwick, Peebles,	1826	11	6	91	1·51	Sir T. Dick Lauder.
Gray, Forfar,	..	11	3	140	0·96	Mr. Hutchison's List.
Drummond Castle, Perth,	1884	14	5	196	0·87	Do.
Do. do.	,,	16	0	196	0·96	Do.
Do. do.	,,	17	5	196	1·06	Do.
Do. do.	,,	18	2	196	1·11	Do.

(*b*) Rate in Trees of known Age, at 4 Feet.

Lochnell, Argyll,	1771	6	3	36	2·08	Dr. Walker.
Do. do.	,,	6	6	36	2·16	Do.
Bargaly, Kirkcudbright,	1780	8	0	83	1·15	Do.
Polkemmet, W. Lothian,	1799	10	0	94	1·27	Do.
Drumlanrig, Dumfries,	1773	12	0	83	1·73	Do.

(*c*) RATE, ASCERTAINED BY GIRTH MEASUREMENT, AT 5 FEET (Mr. Hutchison's Tables).

LOCALITY.	Date.	Girth.		Period.	Rate.
		Ft.	In.	Years.	Inch.
Roseneath, Dumbarton, .	1882	21	8	65	1·12
Do. do. .	,,	22	0	65	1·07

(*d*) A tree at Dalswinton, Dumfries, 8 feet 6 inches in girth in 1860; rate for previous five years, 1·50 inch (Sir R. Christison).

(*e*) RATE OF ROSENEATH TREES, SUPPOSING 1600 TO BE THE DATE OF PLANTING.

Dates.	Increase in Inches		Period.	Rate.	
	"Eve."	"Adam"	Years.	"Eve."	"Adam"
At 1 Foot.					
1600 to 1817, . .	236	238	217	1·08	1·09
1818 ,, 1833, . .	28	51	16	2·18	3·18
1834 ,, 1882, . .	72	57	49	1·47	1·16
	336	346	282	1·19	1·22
At 3 Feet.					
1600 to 1817, . .	210	215	217	0·96	0·99
1818 ,, 1833, . .	10	10	16	0·62	0·62
1834 ,, 1882, . .	52	55	49	1·06	1·12
	272	280	282	0·96	1·00
At 5 Feet.					
1600 to 1817, . .	187	194	217	0·86	0·89
1818 ,, 1833, . .	24	24	16	1·50	1·50
1834 ,, 1882, . .	49	46	49	1·00	0·94
	260	264	282	0·92	0·93

The considerable number of rates given in the tables, although they may not all be strictly reliable, nevertheless agree in showing that this species both grows more quickly and attains a greater size than the native fir. If the measurements of the celebrated trees at Roseneath, given in Mr. Hutchison's table, are to be relied on, increase in girth must be going on about as rapidly at the present

enormous bulk of the trees as it is likely to have done at any previous period, except in very early life. And if it be true that the species was only introduced in Scotland about the year 1600, then these trees must be a little under three centuries old, and they must have increased nearly at the rate of an inch a year (0·92 and 0·93), at 5 feet above ground, over that long period. The measurements, quoted by Mr. Hutchison, at three points in 1817, 1832, and 1882, yield results which, on the whole, agree so well with each other as to inspire considerable confidence in their accuracy. The only exception is the remarkably rapid rate, at one foot up, between 1817 and 1832, both in "Adam" and "Eve," but particularly the former. This may have been due to a sudden expansion in the conoid base, which I have been led to believe, in the present investigation, is apt to take place in very large trees of various species, and which is occasionally confirmed by the rings in tree-sections; or it may be an error of observation, as at 1 foot up the slightest shifting in position of the tape may give very different results. Strutt (Sylva Brit., 1826) gives 268 inches at 1 foot and 209 at 5 feet as the girths of one of these trees. Comparing these with the figures for 1817 in the table, and supposing Strutt's figures to date from 1825 for "Adam," the larger of the two, we get 3·75 for the rate at 1 foot, and 1·87 at 5 feet, for the eight years 1817 to 1825, which agree wonderfully well with the corresponding rates of 3·18 and 1·50 from 1818 to 1833 in the table.

V. The Spruce Fir (*Abies excelsa*).

Notices of large spruce firs are not nearly so numerous as of the silver fir, although the two species were introduced about the same date. I have only two to offer, both taken from the Conifer Conference Statistics of 1891.

Situation.	Girth at 5 feet.		Height.	Authority.
	Ft.	In.	Feet.	
Studley Royal, York,	12	6	132	Mr. John Clark, gardener.
Lynedoch, Perth, .	10	0	106¼	Mr. L. Bayne, forester.

The rate of two young trees girthing $10\frac{2}{10}$ inches and $11\frac{5}{10}$ inches at 5 feet, at Dalswinton, Dumfries, grown under the same conditions as the larches and Scots fir (which see), for eight years, was 1·27 and 1·43, somewhat under that of the Scots fir, and greatly below that of the larches (D. Christison, Ap. 1893).

VI. THE LARCH (*Larix europæa*).

This species was introduced in Scotland by the Duke of Athole in 1727, although it was known in England prior to 1629. Perhaps the period is not yet long enough to establish the size which the species may attain, but one of the original trees at Dunkeld is now (April 1893) 15 feet 1 inch in girth at 5 feet up, although it has probably been growing very slowly for some years back; and another, at Monzie Castle, Perth, is no less than 16 feet 1 inch at the same height. The larch apparently attains, in Scotland, a greater height than the Scots fir, as a rule.

Table of remarkable Scottish larches.

SITUATION.	Girth at 5 feet up. Ft.	In.	Remarks and Authorities.
Annandale, Dumfries,	9	5	Largest on estate (James White, forester).
Arniston, Midlothian,	9	[illegible]	Bole, 60 ft.; height above 100 ft. (D. C., June 1893).
Murthly, Perth, . .	9	8	Largest on estate (D. F. Mackenzie, forester).
Dunkeld, Perth, . .	10	0	115 ft. high (Sir R. Christison, 1879).
Dalswinton, Dumfries,	10	3½	Evidently failing (April 1893, D. Christison)
Hopetoun, W. Lothian,	10	4	78 ft. high (Mr. J. Smith, gardener, 1893).
Brahan Castle, Ross, .	10	9	13 ft. 8 in. at 1 ft.; 11 ft. 6 in. at 3 ft.; 95 ft. high; spread, 38 ft. (W. F. Gunn, 1885).
Keir, Perth, . .	11	3	Sir R. Christison, 1879.
Arniston, Midlothian,	11	5	Bole, 50 ft.; height, above 100 ft. (D. C., 1893).
Duns Castle, Berwick,	12	1	15 ft. at 1 ft. (D. Christison, 1893).
Monzie Castle, Perth,	12	3	About 95 ft. high (George Morgan, wood merchant, Crieff, April 1893).
Glamis, Forfar, . .	12	5	21 ft. 8 in. at ground; 11 ft. 10 in. below the fork, 12 ft. up; 107 ft. high; blown down 1879 (Rev. Dr. Stevenson, Glamis).
Westquarter, Falkirk,	12	7	18 ft. at ground; 16 ft. at 1 ft.; 14 ft. 2 in. at 2 ft.; 13 ft. 8 in. at 3 ft.; 12 ft. 8 in. at 4 ft. (Mr. Livingston to Sir Wyville Thomson, Nov. 1878).
Dalwick, Peebles, .	13	8½	At narrowest of a short stem; 17 ft. 9 in. at 1 ft. 6 in. (D. Christison, 1873).
Do. .	13	·7	At narrowest; 19 ft. 6 in. above the roots; a ruin (D. Christison, 1873).
Dunkeld, Perth, . .	13	11	Sir R. Christison, 1879.
* Do. .	15	1	Height, 102 ft. 4 in. (P. W. Fairgrieve, gardener, April 1893).
Monzie Castle, Perth, .	16	1	100 ft. high (George Morgan, wood merchant, Crieff, April 1893).

* General dimensions of this veteran furnished by Mr. Fairgrieve—

	Ft.	In.		Ft.	In.
Girth at 3 feet, ...	17	2	Girth at 68 feet, ...	6	1
,, 5 feet, ...	15	1	Height, ...	102	4
,, 17 feet, ...	12	10½	Cubic feet with bark, . .	648	0
,, 51 feet, ...	8	8	,, without bark, .	532	0

Rates of larches in several localities (Dr. Walker).

Situation.	Last Observation.	Period.	Girth at 4 Feet.		Rates.		Height.
					If from Seed.	If young Trees.	
	Years.	Years.	Ft.	In.	Inches.	Inches.	Feet.
Leadhills, 1600 feet above sea, .	1773	33	2	3	1·00	0·82	40
Polkemmet, West Lothian, . .	1799	39	5	2	1·71	1·59	..
Dunkeld, several, ...	1770	28	5	5	2·95	2·35	60
*Moffat, ...	1785	12	2	3	2·25	..	28

* From seed; sixteen years old; four years deducted for growth to 4 feet.

Largest of the first two larches planted in Scotland, Dunkeld, 1727; four years added to this date for growth in a greenhouse to 4 feet.

Date.	Period.	Increase.	Rate.	Authority.
	Years.	Inches.	Inches.	
1731 to 1770, .	39	50	1·28 at 4 feet.	Dr. Walker.
1731 to 1878, .	147	177	1·20 at 5 feet.	Sir R. Christison.
1878 to 1892, .	14	4	0·28 do.	Mr. Fairgrieve.

Monzie larch, supposing it to be the same age.

1731 to 1892, .	161	193	1·20 at 5 feet.	Mr. Geo. Morgan.

Four young larches at Dalswinton, Dumfries, planted when 3 feet high, spring 1884, in ground "stubbed" for removal of roots, thus trenched 3 or 4 feet deep. One year allowed for growth to 5 feet (D. Christison, April 1893). Also four old ones at the same place, not thriving latterly (Sir R. Christison, various dates).

Four Young Larches.		
	Girth at 5 Feet.	Rate for Eight Years.
	Inches.	Inches.
No. 1, ...	17·25	2·15
No. 2, ...	16·30	2·00
No. 3, ...	17·60	2·20
No. 4, ...	18·00	2·25

Four Old Larches.

	Last Observation.	Period.	Girth at 5 Feet.		Rate.
		Years.	Ft.	In.	Inch.
No. 1, ...	1875	39	9	3⅛	0·73
No. 2, ...	1860	21	8	10½	1·20
No. 3, ...	,,	24	8	4	0·70
No. 4, ...	1875	21	10	1	0·76
Do.	1892	17	10	3½	0·15

Larch blown down at Glamis, Forfarshire, 1879. Rings counted at 2 feet 4 inches up, above the basic swelling, by the Rev. Dr. Stevenson and Sir R. Christison.

Height.	Girth at 2 ft. 4 in.		Age.	Rate.
Feet.	Ft.	In.	Years.	Inch.
105	12	10	108	1·42

Larch at Hewell Grange, Worcester (Conifer Conference Statistics, 1891).

Height.	Age.	Girth at 5 Feet.	Rate.
Feet.	Years.	Feet.	Inch.
80	75	11	1·75

Young larch, Edinburgh Arboretum (D. Christison).

Last Observation.	Girth.	Period.	Rate.	Best Year.
	Inches.	Years.	Inches.	Inches.
1892	11·35	6	1·23	1·75

The indubitable rate of above 2 inches in young larches at Dalswinton, and of about 1¼ inch for the long period of 160 years in the Dunkeld and Monzie trees, confirms the accuracy of other large results, and proves that the species is a quick grower under favourable circumstances. The four planted in "stubbed" ground at Dalswinton grew more than twice as fast as others close to them planted in undisturbed ground.

2. Coniferæ of Recent Introduction.

The valuable paper contributed to the Conifer Conference of 1891 by Mr. Malcolm Dunn, with tables giving the dimensions of a vast number of the recently introduced Coniferæ, from information furnished to him by practical men in all parts of the United Kingdom, is almost the sole source of the details in the concluding division of my subject. The mass of information contained in these tables is, I believe, unrivalled for extent and accuracy. It might have sufficed to select only the best example of each species, in order to show the size which each has been able to reach in Scotland under the most favourable circumstances, but it seemed more advisable to take two or three of the best in each species, as there was a risk that single examples might be supposed to be altogether exceptional; of course none of these recently introduced species have had time to prove what they can do in the way of producing giants in this country, and our chief interest lies in showing the extraordinary rate at which many of them have grown. I have, therefore, added to my selected examples from Mr. Dunn's tables a calculation of the rate of their girth-increase; and here we are on surer ground than when dealing with long-established species, because, knowing with certainty the date of their introduction, we are at least sure that the existing examples cannot exceed a certain age. In some cases, indeed, Mr. Dunn's informants have themselves planted the trees of which they treat, and in many others the date of planting has been accurately recorded. There is a difficulty in interpreting the "Date of Planting" in the tables, as it may mean either planting of a seed or of a young tree of unknown size. But, I believe, in the vast majority of cases, a seedling 18 inches or 2 feet high is implied. To avoid exaggeration, however, my calculations are all based on the supposition that the trees when planted had reached 5 feet; the height at which all the measurements in Mr. Dunn's tables were taken.

I. Dimensions of recently introduced Conifers, almost all selected from information collected by Mr. Malcolm Dunn for the Conifer Conference (Jour. Hortic. Society, 1891); with the rate of their girth-increase.

Abies.

Intro-duced.	Species.	Situation.	Height.		Age.	Girth at 5 Ft.		Rate.
			Ft.	In.	Yrs.	Ft.	In.	In.
1851	Albertiana,	Cairnies, Perth, . . .	63	0	30	6	9	2·70
,,	Do.	Castle-Menzies, Perth, . .	72	0	38	5	9	2·00
,,	Do.	Dolphinton, Lanark, . .	55	0	27*	3	6	1·70
1824	cephalonica,	Cluny Castle, Aberdeen, . .	..		20*	4	9	3·35
,,	Do.	Whittinghame, East Lothian, .	55	0	45	8	0	2·13
,,	Do.	Castle-Kennedy, Wigtown, .	42	0	42	7	0	2·00
1851	concolor,	Brahan, Ross, ...	40	0	30	7	0	2·80
,,	Do.	Cairnies, Perth, . . .	55	0	30	6	0	2·40
1827	Douglasii	Keir, Perth, ...	45	0	42	11	6	3·28
,,	(Pseudotsuga	Dunrobin, Sutherland, . .	58	0	40	10	10	3·25
,,	Douglasii),	Dunkeld, Perth, . . .	94	0	45	12	0	3·20
,,	Do.	Murthly Castle, Perth, . .	76	0	45	11	9	3·13
,,	Do.	Lynedoch, Perth, . . .	91	9	57	12	0	2·52
,,	Do.	do. do. . . .	72	0	57	11	2	2·35
,,	Do.	Haddo, Aberdeen, . . .	73	0	40	8	1	2·42
,,	Do.	Buchanan Castle, Stirling, .	85	0	†	12	0	2·40
,,	Do.	Dolphinton, Lanark. . .	62	0	41*	7	6	2·31
,,	Do.	Jardine Hall, Dumfries, . .	67	0	63	10	6	2·10
1831	grandis,	Altyre, Moray, ...	60	0	22	7	0	3·81
,,	Do.	Conan, Ross, ...	52	0	18	5	0	3·33
,,	Do.	Dolphinton, Lanark, . .	68	0	20*	5	5	3·61
,,	Do.	Inveraray, Argyll, . . .	45	0	27	7	1	3·14
,,	Do.	Drumlanrig, Dumfries, . .	49	0	20	4	9	2·85
1851	magnifica,	Durris, Kincardine, . . .	45	0	†	4	2	1·42
,,	Do.	Cairnies, Perth, . . .	50	0	30	3	6	1·40
1831	Menziesii	Drumlanrig, Dumfries, . .	49	0	22	7	9	4·22
,,	(Piceasitchensis),	Buchanan Castle, Stirling, .	65	0	35	9	0	3·08
,,	Do.	Keillour, Perth, . . .	95	0	57*	13	9	3·00
,,	Do.	Castle-Menzies, Perth, . .	96	6	46	11	0	2·87
,,	Do.	Scone, Perth, ...	71	0	39	8	5	2·59
1818	Morinda,	Castle-Kennedy, Wigtown, .	50	0	40	4	10	1·45
,,	Do.	Hopetoun, West Lothian, .	76	0	70‡	8	0	1·47
1831	nobilis,	Brahan Castle, Ross, . .	55	0	35	7	9	2·65
,,	Do.	Haddo House, Aberdeen, .	64	0	35	6	6	2·22
,,	Do.	Castle-Kennedy, Wigtown, .	50	0	40	7	0	2·20
,,	Do.	Coul, Ross, ...	77	6	60‡	7	10	1·70
1843	Nordmanniana,	Buchanan Castle, Stirling, .	50	0	35	7	2	2·45
,,	Do.	Altyre, Moray, ...	45	0	22	4	6	2·45
,,	Do.	Poltalloch, Argyll, . . .	70	0	†	6	0	1·90
	Araucaria.							
1796	imbricata,	Dupplin, Perth, ...	54	0	32	5	6	2·06
,,	Do.	Poltalloch, Argyll, . . .	55	6	35	6	0	2·05
,,	Do.	Kilmaron, Fife, . . .	32	0	22	3	5	1·86
,,	Do.	Torloisk, Mull, ...	39	0	40	6	2	1·85
,,	Do.	Duns Castle, Berwick, . .	..		..	6	3	..
,,	Do.	Buchanan Castle, Stirling, .	43	0	35	5	4	1·82
,,	Do.	Duart, Mull, ...	34	6	60(?)	6	11	..
,,	Do.	§Cairnsmore, Kirkcudbright, .	..		25	5	2	2·48
,,	Do.	‖Cardoness, ...	41	6	..	6	6	..
	Cedrus.							
1841	atlantica,	Rossie Priory, Perth, . .	42	0	45	7	9	2·06
,,	Do.	Hopetoun, West Lothian, .	59	0	45	6	8	1·77
,,	Do.	Gordon Castle, Moray, . .	18	0	18	8	6	2·33
1831	deodara,	Whittinghame, East Lothian, .	44	0	45	8	0	2·13
,,	Do.	Gordon Castle, Moray, . . .	42	0	40	6	9	2·02
,,	Do.	Dupplin Castle, Perth, . .	49	0	32	5	4	2·00
,,	Do.	Kilmaron, Fife, . . .	37	0	33	5	4	1·92
,,	Do.	Rossie Priory, Perth, . . .	70	0	(?)	5	9	(?)
	Cryptomeria.							
1841	japonica,	Keir, Perth, ...	42	6	40	9	8	2·90
,,	Do.	Methven, Perth. . . .	30	0	35¶	5	5	1·97
,,	Do.	Whittinghame, East Lothian, .	30	0	30	4	5	1·76

* Two or three years deducted from age given here, to allow for growth to 5 feet, in calculating the rate.

† Age taken from date of introduction of the species, and five years deducted for growth to 5 feet in height.

‡ Five years deducted from age given here, as tree was grown from seed.

§ From measurements in 1880, by Lord Curriehill, at 3 feet 6 inches.

‖ Mr. James Thomson, gardener; girth at ground, 12 feet; 1893.

¶ Two years deducted from age given, for growth to 5 feet.

SEQUOIA GIGANTEA.

Introduced.	Situation.	Height.		Age.	Girth at 5 feet.		Rate.
		Ft.	In.	Yrs.	Ft.	In.	In.
1850 to 1853	Castle-Menzies, Perth, . . .	52	0	35	13	9	5·00
,,	Munches, Kirkcudbright, . .	40	0	25	9	4	4·48
,,	Methven, Perth, ...	61	0	25	7	5	3·80
,,	Rossdhu, Dumbarton, . . .	65	0	*	11	0	3·66
,,	Dupplin, Perth, ...	55	0	28	8	6	3·64
,,	Keir, Perth, ...	52	0	28	8	6	3·64
,,	Castle-Leod, Ross, . . .	61	0	*	10	8	3·42
,,	Altyre, Moray, ...	50	0	25	7	3	3·40
,,	Castle-Kennedy, Wigtown, . .	33	0	30	8	6	3·40
,,	Kilmaron Castle, Fife, . . .	51	0	26	7	4	3·38
,,	Drumlanrig, Dumfries, . . .	47	0	26	7	0	3·23
,,	Murthly Castle, Perth, . . .	66	3	35	9	3	3·17
,,	Gordon Castle, Moray, . . .	52	0	30	7	9	3·10
	TAXODIUM SEMPERVIRENS.						
1846	Murthly Castle, Perth, . . .	45	0	35	8	10	3·02
,,	Dupplin, Perth, ...	60	0	32	7	9	2·90
,,	Kilmaron, Fife, ...	45	9	26	5	9	2·65
,,	Cultoquhey, Perth, . . .	45	0	31	6	6	2·20
,,	Castle-Kennedy, Wigtown, . .	34	0	35	5	10	2·00
	THUYA GIGANTEA.						
1850 to 1853	Keir, Perth, ...	47	0	28	5	4	2·28
,,	Duart, Argyll, ...	46	0	30	5	4	2·13
,,	Buchanan Castle, Stirling, . .	28	0	25	4	4	2·04
,,	Riccarton, Midlothian, . . .	41	0	28	4	3	1·82
,,	Gordon Castle, Moray, . . .	48	0	30	4	9	1·90
,,	Dupplin Castle, Perth, . . .	50	0	30	4	8	1·86

* Age taken from date of introduction of species, and five years deducted for growth to 5 feet, in calculating rate.

CUPRESSUS.

Introduced.	Species.	Situation.	Height.		Age.	Girth at 5 Ft.		Rate.
			Ft.	In.	Yrs.	Ft.	In.	In.
1854	Lawsoniana,	Torloisk, Mull, ...	34	6	35	8	6	*
,,	Do.	Methven, Perth, ...	45	0	33	5	4	2·06
,,	Do.	Dupplin, Perth, ...	55	0	32	4	3	†
1838	macrocarpa,	Castle-Kennedy, Wigtown, .	55	0	35	8	8	2·97
		PINUS.						
1835	austriaca,	Murthly Castle, Perth, . .	30	0	25	5	7	2·68
,,	Do.	Altyre, Moray, ...	35	0	22	4	8	2·53
,,	Do.	Whittinghame, East Lothian, .	51	0	45	6	9	1·80
,,	Do.	Castle-Kennedy, Wigtown, .	45	0	42	6	6	1·73
1827	Cembra,	Abercairney, Perth, . . .	55	0	30	7	0	2·80
,,	Do.	Munches, Kirkcudbright, .	40	0	25	4	3	2·04
,,	excelsa,	do. do. .	60	0	30	6	1	2·43
,,	Do.	Brahan Castle, Ross, . .	30	0	23	3	9	1·95
,,	Do.	Abercairney, Perth, . . .	42	0	30	5	0	2·00
1833	insignis,	Keir, Perth, ...	54	0	40	9	4	2·80
,,	Do.	Castle-Kennedy, Wigtown, .	52	0	42	7	9	2·21
,,	Do.	Bute, ...	57	0	34	4	11	1·73
1852	Jeffreyi,	Fordell, Fife, ...	50	0	35	3	6	1·20
1827	Lambertiana,	Poltalloch, Argyll, . . .	45	0	‡	9	0	1·83
1831	monticola,	Scone, Perth, ...	71	0	39	5	11	1·82
1705	strobus,	Logiealmond, Perth, . . .	90	0	(?)	7	6	..
1825	pinaster,	Haddo, Aberdeen, . . .	43	0	40	6	0	1·80
1834	pyrenaica,	Keir, Perth, ...	35	0	40	5	4	1·60
1759	Laricio,	Altyre, Moray, ...	40	0	22	3	10	2·09
,,	Do.	Keir, Perth, ...	51	0	36	5	10	1·94
,,	Do.	Hopetoun, West Lothian, .	71	0	70	7	3	1·24
,,	Do.	Riccarton, Midlothian, . .	69	0	(?)	7	7½	(?)
1827	ponderosa,	Scone, Perth, ...	50	0	31	6	8½	2·58
,,	Do.	Kilmaron, Fife, ...	40	0	26	4	4	2·0
,,	Do.	Dupplin, Perth, ...	29	0	28	3	5	1·46
,,	Do.	Whittinghame, East Lothian, .	50	0	45	4	6	1·20

* 2·90 inches at 1 foot. † 1·60 or 1·88 inches.

‡ Age from date of introduction of species, and five years deducted for growth to 5 ft.

II. Girth at 5 feet up of some of the finest conifers at Castle-Kennedy, Wigtownshire (Mr. William Cruden, gardener, December 1891).

	Ft.	In.
Abies nobilis,	6	7
Do.	7	0
Do.	7	1
Araucaria imbricata,	5	7
Do.	5	10
Cryptomeria japonica,	4	8
Sequoia gigantea,	9	0
Taxodium sempervirens,	6	1

III. Dimensions and rate of girth-increase of the best conifers of all the species at Dolphinton and Methven, selected from the Conifer Conference Statistics, 1891, because their age is known with exceptional precision.

Mr. Ord Mackenzie has kept a regular record of the planting and progress of his conifers at Dolphinton. They were planted when about 18 inches high, and I have added two years to the date of planting for their growth to 5 feet. The Methven trees were raised from seed, or cuttings, or planted as seedlings 2 feet high. I have added only two years to the date of planting for all for growth to 5 feet.

Conifers at Dolphinton, Lanarkshire (Mr. J. Ord Mackenzie), 1891. Age estimated from the height of 5 feet, the position of girth measurement.

SPECIES.	Height.	Branch Spread.	Age.	Girth.	Rate.
	Feet.	Feet.	Years.	Ft. In.	Inches.
Abies grandis,	68	32	18	5 5	3·61
,, orientalis,	32	15	13	2 9	2·53
,, Menziesii,	60	30	28	5 6	2·35
,, Douglasii,	62	36	39	7 6	2·31
,, magnifica,	28	11	13	2 4	2·30
,, nobilis,	57	26	28	4 9	2·03
,, cephalonica,	37	17	16	2 7	1·93
,, lasiocarpa,	40	19	28	4 0	1·71
,, Albertiana,	55	28	25	3 6	1·70
,, Nordmanniana,	50	18	28	3 10	1·64
Araucaria imbricata,	28	17	38	2 5	0·76
Cupressus Lawsoniana,	29	15	26	2 4	1·07
Sequoia gigantea,	32	15	23	5 6	2·87
Pinus Laricio,	36	15	33	3 6	1·27
Thuya Lobii,	41	15	16	2 4	1·75

Conifers at Methven, Perth (Col. Smythe), 1891. Age estimated as at Dolphinton.

Species.	Height.	Branch Spread.	Age.	Girth.	Rate.
	Feet.	Feet.	Years.	Ft. In.	Inches.
Abies Douglasii, . .	65	33	31	6 10	2·64
,, Albertiana, . .	58	27	21	4 7	2·62
,, grandis . .	35	12	19	4 0	2·52
,, magnifica, . .	25	9	11	2 2	2·36
,, nobilis, . .	35	12	19	2 7	1·63
,, Nordmanniana, .	35	15	20	2 5	1·45
,, Pattoniana, . .	25	10	32	2 2	0·81
,, Hookeriana, . .	15	13	31	1 1	0·40
Araucaria imbricata, .	35	16	33	4 3	1·54
Cedrus atlantica, . .	20	10	33	3 0	1·09
,, deodara, . .	30	10	23	2 8	1·38
Cryptomeria japonica, .	30	12	33	5 5	1·97
Cupressus Lawsoniana, .	45	15	31	5 4	2·06
Libocedrus decurrens, .	25	8	28	3 5	1·46
Thuyopsis borealis, .	37	12	31	3 4	1·29
Sequoia gigantea, . .	61	16	23	7 5	3·80

The following well-authenticated facts are given as illustrating various interesting points in the history of recently introduced conifers :—

I. Dimensions and rate of increase for the last twelve years of three large araucarias at Duns Castle, Berwickshire (Mr. Peter Loney, land steward, Marchmont House), last measurement, 14th September 1892.

	Height.	Girth at		Period.	Increase at		Rate at	
		1 Foot.	5 Feet.		1 Foot.	5 Feet.	1 Foot.	5 Feet.
	Ft. In.	Ft. In.	Ft. In.	Yrs.	In.	In.	In.	In.
No. 1, . .	46 1	8 10	6 3	12	22	15	1·83	1·25
No. 2, . .	43 3	7 3	5 10	12	18	12	1·50	1·00
No. 3, . .	40 6	4 10	4 0	12	16	11	1·33	0·92

This table shows that three araucarias, averaging 5 feet in girth 5 feet up, were growing at an annual rate of 1 inch; that of the largest, upwards of 6 feet in girth, being 1¼ inch. The circumference of the foliage of this magnificent tree, thickly clothed to the ground, is 105 ft. (D. Christison, 1893).

II. Average rate of an araucaria, 27 feet high, and 24 inches in girth, at Stravithie House, Fifeshire, for twenty years, at 5 feet up, 1·20 inch (Dr. Cleghorn, 1891).

III. Annual girth-increase of largest *Ab. Douglasii*, Dolphinton.

1876	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
$3\frac{3}{4}$	4	$2\frac{1}{2}$	2	$\frac{8}{10}$	$2\frac{2}{10}$	$4\frac{1}{2}$	$3\frac{1}{2}$	1	3	$2\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{1}{2}$	$\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$

This table illustrates the extraordinary variation in the rate of girth-increase from year to year of an *Abies Douglasii*, from careful measurements taken by Mr. John Ord Mackenzie of Dolphinton. A considerable annual variation is characteristic of all trees, as I have shown at length in a Paper on the Increase of Girth in Trees (Trans. Bot. Soc. Ed., 1888), but comes out more strikingly in a tree of extraordinarily rapid growth, such as this, than in my ordinary examples. It is curious and worthy of further investigation that this variation would not be suspected from looking at sections of stems, as the width of neighbouring rings seems in general tolerably uniform.

IV. Progressive rate of *Abies Douglasii* at Jardine Hall, Dumfries. (Conifer Conference Statistics, 1891).

Date.	Height.	Girth at								Diameter of Branches.
		Base.		1 Foot.		3 Feet.		5 Feet.		
	Ft.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Feet.
1828	2	...		...		...		...		...
1842	25	...		2	9	...		...		...
1845	...	...		3	8	...		...		...
1875	...	...		11	0	...		8	6	...
1880	...	...		12	0	10	3	...		55
1884	...	15	6	12	7	11	0	10	0	60
1887	70	16	0	...		11	0	10	0	62

Loudon gives the height as 13 feet 2 inches in 1837.

The top is much injured and broken by a colony of rooks which have met there for thirty years (W. H. Maxwell of Munches).

V. Additional instances of great size and rapid growth (Conifer Conference Statistics, 1891).

Abies nobilis, Golden Grove, Caermarthen.

Height.	Age.	Girth at 5 Feet.		Rate.
Feet.	Years.	Ft.	In.	Inches.
48	22	5	11	4·61

As this tree was raised from seed, four years have been deducted from its age of twenty-two years, in calculating the rate of girth-increase at 5 feet up.

Abies Douglasii, Dropmore, Bucks.

Height.	Branch Spread.	Age.	Girth at 5 Feet.	Rate.
Feet.	Feet.	Years.	Ft. In.	Inches.
120	64	60	11 4	2·26

The rate given is supposing the tree planted at five years old. This tree is remarkable for having the greatest recorded height of any Douglas fir in Great Britain.

Abies Douglasii, Dunkeld, Perth.

Height.	Girth at						Age.	Rate at 5 Feet.
	1 Foot.	3 Feet.	5 Feet.	8 Feet.	40 Feet.	75 Feet.		
Feet.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Years.	Inches.
94	14 6	12 6	12 0	9 10	5 9	1 6	45	8·20

The rate given is supposing the tree planted at five years old.

VI. *Abies Douglasii*, Duncrub Park, Perth (Hon. Bernard Rollo, 1893).

Height.	Girth at				Branch Spread.		Age.	Rate at 5 Feet.
	1 Foot.	3 Feet.	5 Feet.	7 Feet.	N. to S.	E. to W.		
Feet.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Years.	Inches.
72	14 8	11 10	12 5	11 9	76 0	77 8	57	2·71

Height lessened by the top being broken in 1881. A healthy new top now formed.

VII. Rapid upward growth (Conif. Conf. Stat. 1891).

Species.	Locality.	Period.	Annual Rate.
		Years.	Ft. In.
Abies Douglasii,	Dropmore, Bucks, . .	60	2 0
Do.	Dunkeld, Perth, . . .	45	2 1
Abies grandis,	Dolphinton, Lanark, . .	4	4 0
Do.	do. (same tree),	20	3 3
Do. (No. 1)	Riccarton, Midlothian, . .	12	4 5
Do. (No. 2)	do. . .	5	4 3
Do.	Conan, Ross, ...	18	2 7
Do.	Altyre, Moray, ...	22	2 6
Abies Menziesii,	Drumlanrig, Dumfries, . .	22	2 0
Do.	Castle-Menzies, Perth, . .	46	2 0
Sequoia gigantea,	Methven Castle, Perth, .	25	2 4

Although the Conifer Conference Statistics prove beyond doubt the occasional very rapid growth of many species of new conifers in this country in early youth, yet their capacity to grow to a great size is in general still unascertained. Indeed, it is the common belief among practical foresters that most of the species cease to flourish before they attain even a moderate size, and this seems borne out by the condition of the celebrated Pinetum at Castle-Kennedy, Wigtownshire, which some years ago was perhaps the most beautiful and promising collection in Britain, but which, on revisiting it last year, I was sorry to find apparently in a declining state. Even the Douglas fir, although promising well, has not yet established its position as a profitable tree. But whatever the commercial value of these conifers may turn out to be, they will always be prized for ornamental purposes.

HISTORIC TREES.

The Boscobel Oak.—One of the necessary but thankless occasional duties of science is to dispel pleasing illusions. This duty generally falls most heavily on the archæologist, or historian, but the forester cannot altogether escape it. It may be asked, why disturb alluring beliefs, although they may be false? To this, science replies that they ought to be contradicted because they are false, and because there is no knowing how far-reaching the consequences of falsehoods may be.

It is chiefly the oak, among trees, that has been associated with heroic names or historic deeds, and perhaps none has acquired so universal fame and credit as the Boscobel Oak, reputed to have concealed King Charles II. after the battle of Worcester in 1651. An inscription placed against the present tree by Miss Evans in 1875 certifies: "This tree, under the blessing of Almighty God, had the honour of sheltering from his foes King Charles II." But Mr. Robert F. Collins (Trans. N. Staffordshire Field Club, 1890) shows that this tree, being only 11 feet 10 inches in girth, could not have been the pollard oak of nearly two and a half centuries ago, and that a previous inscription in 1817 testified that "the present

tree sprung, it is said, from the above tree" (meaning the Royal tree). It also referred to previous inscriptions, from which it is plain that the original tree disappeared soon after 1787. Indeed, Dr. Stukely informs us that in 1713 "the tree was in the middle almost cut away by people who came to see it."

Wallace Oaks.—Two oaks have been associated with the name of the Scottish hero. The Ellerslie Oak.—According to the legend, "Sir William Wallace and 300 of his men hid themselves among its branches from the English" (Semple's continuation of Crawford's History of Renfrewshire, 1783). But its trunk is described as being "about 12 feet in circumference," an altogether trifling girth for a tree reputed to be then five centuries old. Strutt, 1826, gives the girth as 13 feet 2 inches. The Torwood Wallace Oak was estimated by Dr. Walker in 1775 to have been 22 feet in girth at 4 feet up, but only one longitudinal half of the trunk remained, and it has long entirely disappeared.

Historic Hawthorns.—A thorn is credited with having witnessed the death of Lord Maxwell at the battle of Dryfe Sands, and several have been associated with Mary Queen of Scots, but it is scarcely possible that any hawthorn could exist for 300 years, as the species rarely exceeds a very moderate size, and my observations show that it grows at a fair average rate.

Report on Temperature and Vegetation in the Royal Botanic Garden, during July, August, September, and October 1892. By Robert Lindsay, Curator of the Garden.

JULY.

The weather of July was, for the most part, cool and unsettled, with heavy falls of rain, and with one or two gales of much severity for the time of year. The lowest night temperature was 40°, which occurred on the 10th of the month, and the highest 54°, on the 31st. The lowest day temperature was 55°, on the 12th, and the highest 79°,

on the 31st. The growth of trees and shrubs during the month was fairly good. Most herbaceous plants flowered very well, and roses were very fine towards the end of the month.

On the rock-garden 237 species and well-marked varieties came into flower, as against 252 for the corresponding month last year. A few of the more interesting were:—*Convolvulus lineatus, Cyananthus lobatus, Dianthus cinnabarinus, Epilobium Fleischerii, E. obcordatum, Erythræa diffusa, Eriogonum aureum, Gentiana septemfida cordifolia, Gillenia trifoliata, Kniphofia caulescens, Linaria origanifolia, Meconopsis Wallichii, Primula Poissonii, Saxifraga diversifolia, S. fimbriata, Silene Elizabethæ.*

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during July 1892.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	47°	61°	66°	17th	46	52	69
2nd	49	58	71	18th	48	55	66
3rd	53	59	69	19th	47	52	63
4th	45	59	65	20th	43	53	65
5th	50	63	66	21st	47	53	65
6th	45	53	69	22nd	52	61	69
7th	54	59	65	23rd	44	62	76
8th	49	57	61	24th	45	66	74
9th	47	57	69	25th	45	54	67
10th	40	60	72	26th	46	52	69
11th	48	52	60	27th	40	55	66
12th	49	51	55	28th	50	65	68
13th	49	55	63	29th	48	51	65
14th	51	53	67	30th	48	59	77
15th	47	55	63	31st	54	61	79
16th	45	55	67				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of July 1892.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass.				Direction of Wind.	Clouds.			Rainfall. (Inches.)
		S. R. Thermometers for preceding 24 hours.		Hygrometer.						
		Max.	Min.	Dry.	Wet.		Kind.	Amount.	Direction.	
		°	°	°	°					
1	30·020	67·7	49·7	59·6	54·7	W.	Cum.	9	W.	0·000
2	29·927	62·0	46·9	56·9	54·4	Var.	Cum.	10	S.	0·045
3	29·622	64·5	56·9	58·9	57·3	Calm.	Cum.	10	S.W.	0·270
4	29·645	63·8	52·0	52·2	51·2	W.	Cum.	10	W.	0·090
5	29·486	64·0	51·9	61·8	56·2	W.S.W.	Cum.	6	W.S.W.	0·020
6	29·593	64·7	47·9	55·1	51·3	W.	Cir.Cum. Cum.	7 1	W.	0·125
7	29·108	64·8	52·8	58·3	55·1	W.S.W.	Cum.	10	W.S.W.	0·020
8	29·480	61·5	49·0	58·4	52·9	W.	Cir. Cum.	3 2	W.	0·005
9	29·820	63·0	49·9	57·1	53·1	W.	Cum.	10	W.	0·005
10	29·949	64·0	43·6	57·9	53·6	N.E.	Cir. Cum.	2 1	N.E.	0·000
11	29·965	66·0	49·1	51·1	50·5	E.N.E.	St.	10	E.N.E.	0·000
12	29·794	58·8	49·4	50 7	49·0	E.N.E.	Nim.	10	E.N.E.	0·020
13	29·682	54·2	47·9	54·2	51·1	N.E.	Cum.	5	N.E.	0·000
14	29·869	57·9	48·3	50·5	48·1	E.	Cum.	10	E.	0·000
15	29·945	58·0	49·8	52·5	49·1	E.	Cum.	10	E.	0·000
16	29·893	58·0	49·0	55·4	50·0	N.E.	Cum.	5	N.E.	0·000
17	29·862	61·2	48·9	51·9	47·2	N.E.	Cum.	10	N.E.	0·000
18	29·839	59·7	44·7	53·8	50·2	N.W.	Cum.	5	N.W.	0·310
19	29·421	59·0	49·9	53·1	52·8	W.S.W.	Nim.	10	W.S.W.	0·070
20	30·059	61·5	48·7	53·2	50·2	N.N.E.	Cum.	10	N.N.E.	0·000
21	30·123	59 8	41·6	59·8	55·3	W.	Cir.	4	N.	0·000
22	30·136	69·5	55·0	61·3	56·8	W.	Cum.	9	W.	0·000
23	30·197	66·2	49·0	61·7	56·1	N.W.	Cir.	3	N.W.	0·000
24	30·276	68·0	47·9	61·7	57·3	E.	...	0	...	0·000
25	30·243	68·8	49·8	52·9	52·3	E.	Cum.	10	E.	0·000
26	30·236	59·9	51·0	56·1	54·0	E.	Cum.	10	E.	0·000
27	30·290	63·8	43·4	54·6	52·7	E.	Cum.	10	E.	0·000
28	30·272	60·0	52·9	59·1	53·4	E.	Cum.	1	E.	0·000
29	30·248	63·0	50·8	52·2	51·1	E.	Cum.	10	E.	0·000
30	30·158	58·2	50·9	54·8	53·4	W.	Cum.	10	W.	0·010
31	29·889	70·0	53·9	61·0	58·8	W.	Cum.	10	W.	0·000

Barometer.—Highest Reading, on the 27th, = 30·290. Lowest Reading, on the 7th, = 29·108. Difference, or Monthly Range, = 1·182. Mean = 29·905.

S. R. Thermometers.—Highest Reading, on the 31st, = 70°·0. Lowest Reading, on the 21st, = 41°·6. Difference, or Monthly Range, = 28°·4. Mean of all the Highest = 62°·6. Mean of all the Lowest = 49°·4. Difference, or Mean Daily Range, = 13°·2. Mean Temperature of Month = 56°·0.

Hygrometer.—Mean of Dry Bulb = 56°·0. Mean of Wet Bulb = 52°·9.

Rainfall.—Number of Days on which Rain fell = 12. Amount of Fall, in inches, = 0·990.

A. D. RICHARDSON,
Observer.

AUGUST.

August was a most inclement month. No really warm days occurred, and altogether the month was a most unfavourable one. The lowest night temperature was 35°, which occurred on the 10th of the month, and the highest 58°, on the 14th. The lowest day temperature was 51°, on the 8th, and the highest 74°, on the 13th.

On the rock-garden 103 species and varieties came into flower, as against 84 during last August. Amongst the most conspicuous or interesting were:—*Campanula isophylla alba*, *C. Waldsteiniana*, *Castanea chrysophylla*, *Coreopsis grandiflora*, *Chelone barbata*, *Dianthus Atkinsonii*, *D. glauca*, *Gentiana asclepiadea*, *G. asclepiadea alba*, *G. ornata*, *G. tibetica*, *G. arvernensis*, *Lobelia cardinalis*, *Monarda Kalmiana*, *Olearia Haastii*, *Papaver pyrenaicum*, *Scabiosa fumariæfolia*, *Senecio speciosus*, *Spiræa Bumalda*, *Symphiandra Hoffmanii*, *Veronica longifolia subsessilis*, *V. lycopodioides*, *Viola cornuta* × *tricolor*.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during August 1892.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	56°	64°	66°	17th	47°	53°	59°
2nd	48	54	70	18th	48	55	59
3rd	50	58	70	19th	47	59	69
4th	39	59	69	20th	37	57	69
5th	47	55	70	21st	54	64	70
6th	46	57	68	22nd	56	66	73
7th	44	60	72	23rd	50	63	74
8th	46	50	51	24th	49	57	68
9th	46	50	51	25th	52	57	70
10th	35	62	69	26th	47	57	68
11th	44	52	70	27th	46	58	67
12th	50	60	73	28th	43	61	65
13th	54	59	74	29th	37	54	68
14th	58	64	70	30th	45	55	69
15th	50	63	69	31st	51	54	57
16th	47	54	68				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of August 1892.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·839	71·4	56·0	63·5	59·1	N.W.	Cum.	9	N.	0·030
2	30·050	63·9	49·9	54·0	51·4	S. E.	Cum.	10	S.E.	0·000
3	29·907	63·8	53·1	59·8	54·2	W.S.W.	...	0	...	0·050
4	29·963	68·0	41·0	57·3	50·3	N.W.	Cir. / Cum.	2 / 3	N.W.	0·000
5	29·797	64·8	51·0	56·1	53·1	S. W.	Cum.	10	S.W.	0·075
6	29·570	67·1	49·7	60·2	54·3	W.	Cum.	3	W.	0·000
7	29·839	65·7	45·7	61·4	54·0	N.W.	Cir.	1	N.W.	0·680
8	29·734	65·7	50·1	50·8	50·1	E.	Nim.	10	E.	0·420
9	29·977	53·7	47·0	53·0	47·2	N.	Cum.	8	N.E.	0·000
10	30·127	58·9	39·8	58·5	53·1	W.	...	0	...	0·070
11	29·927	66·4	47·0	57·3	55·8	W.	Cum.	10	W.	0·045
12	29·840	65·8	53·1	60·4	57·9	S.W.	Cum.	10	S.W.	0·045
13	29·393	68·0	58·1	60·3	58·3	S.W.	Nim.	10	S.W.	0·400
14	29·391	69·6	53·6	64·2	59·0	S.W.	Cir.	5	S.W.	0·475
15	29·467	67·8	52·9	61·0	55·4	W.	Cum.	1	W.	0·000
16	29·868	65·6	50·4	62·8	57·2	W.S.W.	Cum.	8	W.S.W.	0·100
17	29·821	65·6	50·6	59·3	57·3	W.	Cum.	4	W.	0·030
18	29·818	64·6	51·0	54·9	53·3	S.S.E.	Nim.	10	S.S.E.	0·200
19	29·627	57·0	51·6	56·9	55·5	Calm.	Cum.	10	N.W.	0·000
20	29·871	64·0	42·2	60·1	56·1	W.	...	0	...	0·010
21	29·866	68·8	58·8	66·5	62·9	S.W.	Cir.	8	S.W.	0·000
22	29·888	70·8	61·2	67·7	62·7	S.W.	Cir. St.	6	S.W.	0·000
23	29·729	72·5	52·9	62·2	59·2	S.	...	0	...	0·060
24	29·672	67·3	55·3	57·1	57·0	N.E.	Cum.	10	N.E.	0·005
25	29·578	61·4	53·5	59·6	55·4	S.W.	Cir.	4	S.	0·000
26	29·710	67·7	50·0	59·4	53·1	W.	Cum.	2	W.	0·190
27	29·408	64·5	48·1	57·4	53·1	W.S.W.	...	0	...	0·000
28	29·391	64·0	47·8	59·5	53·4	W.N.W.	...	0	...	0·020
29	29·631	64·8	38·3	52·2	47·2	N.E	Cir.	2	S.W.	0·810
30	29·264	56·9	48·5	57·2	56·9	Calm.	Cum.	10	S.W.	0·650
31	29·202	60·6	53·7	55·3	55·2	N.	Nim.	10	N.	0·280

Barometer.—Highest Reading, on the 10th, = 30·127. Lowest Reading, on the 31st, = 29·202. Difference, or Monthly Range, = 0·925. Mean = 29·716.

S. R. Thermometers.—Highest Reading, on the 23rd, = 72°·5. Lowest Reading, on the 29th, = 38°·3. Difference, or Monthly Range, = 34°·2. Mean of all the Highest = 65°·1. Mean of all the Lowest = 50°·4. Difference, or Mean Daily Range, = 14°·7. Mean Temperature of Month = 57°·7.

Hygrometer.—Mean of Dry Bulb 58°·9. Mean of Wet Bulb = 55°·1.

Rainfall.—Number of Days on which Rain fell 21. Amount of Fall, in inches = 4·645.

A. D. RICHARDSON,
Observer.

SEPTEMBER.

The month of September was cool and unsettled throughout. No frost occurred, but the average temperature was very low. The greatest deficiency of heat occurred during the day. There was an entire absence of anything in the shape of warm weather. The lowest night temperature was 35°, which occurred on the 30th of the month, and the highest 55°, on the 13th. The lowest day temperature was 52°, on the 28th, and the highest 69°, on the 6th.

Most herbaceous plants flowered very well this month, particularly species of *Aster*, *Rudbeckia*, *Pyrethrum*, and other compositæ. *Colchicum*, *Kniphofia*, and *Crocus* were also fine. Roses flowered fairly well in September. Autumn tints began to show on *Pavia flava* about the middle of the month, and towards the close the golden-yellow leaves were most beautiful and effective.

On the rock-garden 45 plants came into flower, as against 41 for the corresponding month last year, amongst which were the following:—*Colchicum speciosum maximum*, *C. striatum*, *Carlina subcaulescens*, *Centaurea alpina*, *Coreopsis verticillata*, *Crocus annulatus*, *C. medius*, *C. nudiflorus*, *Delphinium nudicaule aurantiacum*, *Gentiana alba*, *Gladiolus Saundersii*, *Hypericum patulum*, *Kniphofia nobilis*, *Liatris elegans*, *Lilium auratum macranthum*, *Montbretia* ("Star of Fire"), *Potentilla formosa*, *Senecio pulcher*, *Teucrium flavum*.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during September 1892.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	43°	54°	61°	16th	47°	51°	61°
2nd	41	57	59	17th	42	53	63
3rd	40	47	60	18th	50	51	62
4th	40	50	68	19th	46	51	64
5th	37	52	67	20th	47	50	55
6th	50	58	69	21st	45	52	58
7th	40	52	60	22nd	36	48	58
8th	36	53	65	23rd	43	47	60
9th	40	55	66	24th	42	52	58
10th	45	58	69	25th	46	57	63
11th	47	58	68	26th	44	52	64
12th	48	56	64	27th	38	55	60
13th	55	61	67	28th	39	45	52
14th	41	53	63	29th	37	42	54
15th	48	54	65	30th	35	42	55

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of September 1892.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9.A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours.		Hygrometer.		Direction of Wind.	Clouds.			Rainfall. (Inches.)
		Max.	Min.	Dry.	Wet.		Kind.	Amount.	Direction.	
		°	°	°	°					
1	29·439	56·8	46·2	55·0	52·3	S.W.	Cum.	10	S.W.	0·120
2	29·196	58·2	44·4	55·7	52·4	W.	Cum.	8	W.	0·105
3	29·399	58·8	43·8	50·2	46·7	W.	Cum.	10	N.W.	0·000
4	30·045	56·8	41·1	52·3	47·7	N.W.	Cum.	1	N.W.	0·000
5	30·130	59·8	39·8	53·5	50·1	S.W.	Cir.	4	W.	0·005
6	30·047	61·3	52·4	58·7	56·0	S.W.	Cir.	7	S.W.	0·005
7	29·780	62·8	46·0	55·1	53·1	S.W.	Cum.	10	S.W.	0·045
8	29·983	57·0	38·5	54·3	51·2	W.	...	0	...	0·000
9	29·714	60·8	44·4	55·9	53·4	S.W.	Cum.	8	S.W.	0·000
10	29·739	62·9	48·9	57·9	54·0	S.W.	Cum.	1	N.W.	0·000
11	29·682	63·9	44·9	57·0	52·4	W.S.W.	Cum.	7	W.	0·020
12	29·678	60·7	48·2	55·3	53·6	W.	Cum.	9	S.W.	0·005
13	29·291	62·0	55·3	61·6	58·7	S.W.	Cum.	2	S.W.	0·000
14	29·804	65·1	42·2	53·6	50·8	S.W.	Cum.	9	S.W.	0·012
15	29·623	59·2	52·4	56·2	53·1	S.S.W.	Cum.	9	S.W.	0·000
16	29·300	60·7	52·2	55·3	50·5	S.S.W.	Cir. Cum.	3	S.S.W.	0·000
17	29·851	58·0	40·1	51·5	46·8	W.S.W.	Cum.	2	N.W.	0·007
18	29·635	57·3	50·8	54·9	52·0	S.W.	Nim.	6	W.	0·103
19	29·507	59·5	51·5	58·3	55·9	W.	Cum.	2	W.	0·054
20	29·936	62·4	47·0	48·4	46·5	E.	Nim.	10	E.	0·000
21	30·099	53·2	46·9	48·9	44·3	E.N.E.	Cum.	9	E.	0·000
22	30·176	53·2	40·1	49·8	45·8	E.N.E.	Cum.	8	E.	0·000
23	29·957	56·1	47·9	49·5	48·8	E.	...	0	...	0·198
24	29·474	57·5	45·3	51·7	48·2	W.S.W.	Cum.	3	W.	0·005
25	29·322	56·8	48·0	56·7	53·3	W.S.W.	Cum.	5	S.W.	0·080
26	29·690	61·6	46·0	54·1	50·7	S.W.	Cum.	6	S.W.	0·085
27	29·141	61·4	53·7	57·0	55·1	S.W.	Nim.	10	S.W.	0·180
28	29·475	57 6	40·8	47·8	44·2	S.W.	...	0	...	0·030
29	29·231	53·6	41·4	49·4	46·1	W.S.W.	Cum.	10	W.S.W.	0·020
30	29·237	52·5	38·2	44·8	43·1	S.	Cir.	5	S.	0·010

Barometer.—Highest Reading, on the 22nd, = 30·176. Lowest Reading, on the 27th, = 29·141. Difference, or Monthly Range, = 1·035. Mean = 29·653.

S. R. Thermometers.—Highest Reading, on the 14th, = 65°·1. Lowest Reading, on the 30th, = 38°·2. Difference, or Monthly Range, = 26°·9 Mean of all the Highest = 58°·9. Mean of all the Lowest = 45°·9. Difference, or Mean Daily Range, = 13°·0. Mean Temperature of Month = 52°·4.

Hygrometer.—Mean of Dry Bulb = 53°·7. Mean of Wet Bulb = 50°·6.

Rainfall.—Number of Days on which Rain fell = 19. Amount of Fall, in inches, = 1·089.

A. D. RICHARDSON,
A. ANDERSON, } *Observers.*

OCTOBER.

The month was very cold, with much frost and rain. The first frost this season was on the 2nd, when the glass registered 32°. The thermometer was at or below the freezing point on nine occasions, indicating collectively 44° of frost for the month. The lowest readings were on the 18th, 26°; 19th, 28°; 24th, 23°; 25th, 19°; 26th, 20°. The lowest day reading was 44° on the 25th, and the highest 62° on the 2nd. Leaves of deciduous trees and shrubs began to fall early in the month. Autumn tints were most conspicuous on species of Oak, Maple, *Cornus*, *Azalea*, *Pyrus*, and *Berberis.* The brown tint on varieties of *Biota* is also very distinct and interesting. Fruit is most abundant on trees of *Pyrus latifolia*, Holly Cotoneaster, and *Pernettya.* Flowering herbaceous plants continued to bloom till the frost of the 25th. Large masses of *Polygonum vaccinifolium* on the rock-garden were completely destroyed at the same date.

On the rock-garden 15 species came into flower during October, as against 13 for October 1891. Amongst those were:—*Aster longifolius*, *Crocus asturicus*, *C. Salzmannii*, *Helleborus albicans*, *Hypericum nepalense*, *Parochætus communis*, *Rudbeckia Newmannii*, *Sedum spectabile*, *Statice minuta.* The total which have flowered since 1st January is 1208. During the same period last year 1210 flowered.

Readings of exposed Thermometer at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during October 1892.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	34°	40°	45°	17th	35	43	50
2nd	32	42	62	18th	26	35	51
3rd	37	45	51	19th	28	40	51
4th	42	45	55	20th	37	39	51
5th	39	43	51	21st	34	36	46
6th	36	47	61	22nd	32	38	47
7th	41	44	52	23rd	32	40	45
8th	39	41	53	24th	23	38	46
9th	36	50	56	25th	19	25	44
10th	38	45	52	26th	20	27	45
11th	33	45	56	27th	32	39	52
12th	33	41	54	28th	45	54	61
13th	44	46	55	29th	46	51	60
14th	43	50	54	30th	37	44	54
15th	44	46	55	31st	34	38	50
16th	34	42	48				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of October 1892.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·266	50·5	37·5	42·0	41·8	Calm.	Cir.	5	S.W.	0·420
2	29·366	50·0	36·0	45·0	44·8	S.	Nim.	10	E.	0·120
3	29·614	50·1	38·0	48·6	47·8	N.E.	Nim.	10	N.E.	0·945
4	29·550	50·9	46·0	46·4	46·1	Calm.	Nim.	10	E.	0·300
5	29·242	52·5	43·0	44·8	44·8	Calm.	Nim.	10	N.E.	0·280
6	29·142	49·8	44·5	49·8	46·1	S.W.	Cum.	9	S.W.	0·030
7	29·110	56·7	43·8	45·8	44·4	S.W.	Cir. St.	10	N.	0·100
8	29·318	50·7	41·0	41·9	39·7	W.	Cir. St.	10	N.W.	0·175
9	28·764	50·8	40·6	45·8	44 0	W.	Cir. Cum.	2 3	W.	0·070
10	29·532	51·0	40·0	45·0	42·5	N.W.	Cum.	4	N.	0·010
11	29·964	49·8	34·1	42·9	42·0	S.W.	Nim.	10	N.	0·005
12	30·115	51·8	35·2	41·9	40·0	W.	Cum.	5	N.	0·005
13	30·096	48·8	41·0	47·9	44·8	N.E.	Cum.	10	N.E.	0·250
14	30·063	50·8	46·8	50·1	48·0	E.N.E.	Cum.	5	E.N.E.	0·020
15	29·992	51·9	45·8	46·8	44·7	E.N.E.	Cum.	10	E.N.E.	0·025
16	29·896	47·0	38·0	42·9	40·0	N.N.E.	Cum.	9	N.N.E.	0·005
17	30·067	47·1	36·8	40·7	37·9	N.N.W.	Cir. St.	8	N.	0·000
18	30·273	45·1	29·2	35·1	34·0	W.	...	0	...	0·000
19	30·120	49·3	29·0	47·3	41·6	W.	Cir.	6	N.W.	0·000
20	29·966	49·8	39·0	41·8	40·4	N.W.	Cum.	10	N.W.	0·230
21	29·606	47·0	37·9	39·4	39·0	N.	Cum.	10	N.	0·000
22	29·588	43·9	34·1	39·2	36·1	N.W.	Cir. St.	10	N.W.	0·000
23	29·442	43·8	33·9	40·3	36·2	N.W.	Cir.	1	N.	0·030
24	29·691	44·1	35·2	37·4	35·4	N.W.	Cir.	8	N.W.	0·000
25	29·805	43·0	23·0	27·7	26·7	W.	...	0	...	0·000
26	29·924	39·9	23·7	28·4	27·9	N.W.	...	0	...	0·140
27	29·282	42·9	27·7	42·7	41·5	S.	Cum.	10	S.	0·155
28	28·941	53·3	41·8	53·4	51·6	S.W.	Cum.	2	S.W.	0·055
29	28·941	58·0	48·6	52·2	51·1	S.	Cum.	10	S.	0·070
30	29·486	56 9	38·6	42·1	40·2	S.S.W.	...	0	...	0·010
31	29·593	49·5	35·9	38·2	38·0	S.W.	...	0	...	0·000

Barometer.—Highest Reading, on the 18th, = 30·273. Lowest Reading, on the 9th, = 28·764. Difference, or Monthly Range, = 1·509. Mean = 29·637.

S. R. Thermometers.—Highest Reading, on the 29th, = 58°·0. Lowest Reading, on the 25th, = 23°·0. Difference, or Monthly Range, = 35°·0. Mean of all the Highest = 49°·2. Mean of all the Lowest = 37°·3. Difference, or Mean Daily Range, = 12°·1. Mean Temperature of Month = 43°·2.

Hygrometer.—Mean of Dry Bulb = 43°·0. Mean of Wet Bulb = 41°·3.

Rainfall.—Number of Days on which Rain fell — 23. Amount of Fall, in inches, = 3·450.

A. D. RICHARDSON,
Observer.

SUPPLEMENTARY NOTES ON THE MARINE ALGAE OF THE ORKNEY ISLANDS. By GEORGE WM. TRAILL.

(With Zincograph.)

(Read at the Meeting of the Society on February 11, 1892.)

While on a few weeks' visit to South Ronaldsay, in Orkney, last summer, seeing that the Marine Algae of the island had been comparatively little studied, I devoted my attention to the subject in the hope of being successful in finding new species to add to the Orkney list.

The island is seven and a half miles long, by about three in average breadth, and is deeply intersected with bays.

A coast of this extent might be thought likely to yield fair results; but, from my having been unable to dredge, and having thus had to confine myself almost exclusively to the littoral Algae, the results are unfortunately not so good as I might otherwise have been able to show.

I found above 115 species. These being, as a rule, very similar to the littoral Algae enumerated in my Orkney list, I shall mention only those which are of special interest, including several not hitherto recorded.

Calothrix pulvinata (Mert.), Ag.—At the west of St. Margaret's Hope, near "The Needle"; chiefly on the sides of grassy tufts covered by the sea at high tides only. Now first recorded as an Orkney species.

Calothrix scopulorum (Web. and Mohr.), Ag.—At Kirkness in abundance, on smooth, flat rocks near high-water mark. Now first recorded as an Orkney species.

Prasiola stipitata, Suhr.—Occurs sparingly at the east of Harrabrough Head, on rocks and large stones in shaded places exposed to the north, at about the high-water mark of neap tides. The only other Orkney locality recorded is Scapa Bay, where I found it in 1887, but it is scarce there also.

Bryopsis plumosa (Huds.), Ag.—At Kirkness, very fine in pools at about half-tide level; also at the east of Harrabrough Head, but not so large.

Vaucheria sphaerospora, Nordst.; *f. genuina*, Nordst.; *f. dioica*, Nordst.—At the Oyce of Quindry; at the west side

of St. Margaret's Hope; near Howe Taing, Hoxa, etc.; usually on the muddy sides of grassy tufts near high-water mark.

Dictyosiphon hippuroides (Lyngb.), Kütz, forma *fragilis* (Harv.), Kjellm. In Kjellman, "The Algae of the Arctic Sea," page 268.—At St. Peter's Point, on an exposed open

coast, growing on the rock in pools at about half-tide level, in characteristic specimens from six to ten inches high, with zöosporangia. I forwarded one of the specimens to Professor Kjellman, of Upsala, and am indebted to him for kindly identifying the plant. This is now first recorded as a British form. (See Illustration previous page.)

Stictyosiphon tortilis (Rupr.), Rke.—At Roeberry Taing in considerable abundance in sandy pools at about half-tide level. This species has only once before been found in Orkney, namely, one specimen at Holm, East Mainland, by Mr. J. W. Cursiter.

Callithamnion arbuscula (Dillw.), Lyngb. — In great abundance, and of large size on flat rocks near low-water mark, east of Harrabrough Head, at a place where there is generally considerable surf. These are by far the finest Orkney specimens I have seen.

Catenella Opuntia (Good. and Wood.), Grev.—In dark crevices near high-water mark, at the east of Harrabrough Head, sometimes in very fine specimens.

Rhodymenia palmata (Linn.), Grev., forma *sarniensis* (Mert.) Grev.; also var. B. *tenuissima*, Turn.—In Kjellman "The Algae of the Arctic Sea, page 148. In Turn. Hist. Fuc. 1, page 96.—This form and variety occur on the shores of St. Margaret's Hope, and at similar sheltered places around the coast of the island, in large, bushy tufts, and sometimes in immense quantities. The typical form seldom, if ever, accompanies them. The variety, B. *tenuissima*, for the identification of which I am indebted to Prof. Kjellman, is now first recorded as having been found in Orkney.

Corallina mediterranea, Aresch.—At Kirkness in pools at about half-tide level, rare. I am indebted to Mr. Batters for kindly identifying the plant. It is now first recorded as an Orkney species.

Callithamnion byssoides, Arn.—Found many years ago by Mr. Pollexfen in Kirkwall Bay, epiphytic on *Desmarestia aculeata*. Determined by Harvey.

Phyllophora Brodiæ (Turn.), J. Ag., forma *angustissima*, C. Ag.—This form occurs in the Loch of Stenness.

MEETING OF THE SOCIETY,

Thursday, December 8, 1892.

Dr. DAVID CHRISTISON, President, in the Chair.

Rev. GEORGE GUNN, M.A., T. CUTHBERT DAY, and R. STEWART, S.S.C., were elected Resident Fellows of the Society.

Dr. KARL GOEBEL, Professor of Botany in the University and Director of the Botanic Garden, Munich, and GRAF H. ZU SOLMS LAUBACH, Professor of Botany in the University and Director of the Botanic Garden, Strassburg, were, on the recommendation of the Council, chosen Foreign Honorary Fellows of the Society.

The death of JAMES LILBURNE, R.N., M.D., Fellow of the Society, was announced.

Presents to the Library at the Royal Botanic Garden were announced.

The CURATOR exhibited a seedling, *Eichhornia* (*Pontederia*) *crassipes*, from the Royal Botanic Garden, showing the linear first-formed submerged leaves and the later aerial leaves.

Professor BAYLEY BALFOUR exhibited a young carpel of *Cycas Ruminiana* from a plant in flower in the Royal Botanic Garden.

Mr. CAMPBELL sent for exhibition specimens of *Genista fragrans*, *Escallonia macrantha*, some species of *Veronica*, and of *Tritoma*, and of *Passiflora*, all in flower in open air in his garden at Ledaig, Argyllshire.

The PRESIDENT exhibited a seed of *Ipomœa tuberosa* found on the shore of Uist. He read a note by the late Sir Robert Christison in which mention was made of three

Issued November 1893.

other species of tropical fruits also found in Uist, and which had been sent him by Dr. Macdonald, of Lochmaddy. These were *Entada gigantea*, *Dolichos vulgaris*, and *Guilandina Bonduc*, all West Indian fruits carried by the Gulf Stream and stranded on the Outer Hebrides. In a letter sent to Dr. Christison with the seed, Dr. Stewart of Ardgour mentioned that the natives of Uist call this seed "Airne Moire," (Virgin) Mary's kidney, on account of the colour and the presence of a roughly marked cross on one of the surfaces. It was referred to by Martin in 1692 under the name of "Molluscan bean," while Pennant calls it "Jamaica bean."

The following Papers were read:—

EXCURSION OF THE SCOTTISH ALPINE BOTANICAL CLUB TO KILLIN, IN JULY 1892. By CHARLES STUART, M.D.

On Monday, 18th July 1892, the following members of the Club—W. B. Boyd, President; Rev. David Paul, Rev. W. W. Peyton, P. Neill Fraser, George H. Potts, Captain F. M. Norman, and Dr. Charles Stuart—left Edinburgh for Killin. They travelled in a reserved carriage, by the Caledonian Railway, and reached Killin about 7 P.M., where they were comfortably accommodated at Maisie's Hotel. They were accompanied by Rev. George Gunn and Mr. Milne.

Tuesday, 19th July.—This day, unfortunately, was very wet and stormy, the mist was down to the hotel doors, and mountain climbing was out of the question. A lull having taken place about eleven o'clock, Mackintoshes were donned, and a start was made for a walk up the Lochay as far as Tirai. Furious blasts of wind from the north blew sheets of rain in our faces, so that matters were far from comfortable at first. Between showers we botanized on both sides of the road. On the meadows sloping down to the river Lochay, *Orchis maculata*, L., var. *alba*; *Habenaria conopsea*, Benth.; *H. bifolia*, Br.; *H. chlorantha*, Bab., were abundant. On the old wall bordering the road many good mosses were gathered of a sub-alpine type. A raid was

made up the steep banks of the Finlarig woods, where some good forms of *Nephrodium Oreopteris*, Desv., were obtained by Mr. Fraser.

Wednesday, 20th July.—The excursion to-day was to Meall-nan-Tarmachan. Driving four miles to where the road to Glen Lyon branches off from the Kenmore road, a walk of five miles brought us to Lochan-na-Lairige, which is situated on the watershed. It is surrounded by high mountains, but, on the west side, a range of promising-looking ledges, covered at this season with greenery and alpine flowers, appeared to give us hope of something good. The Minister of Killin and the Supervisor of Excise joined our party, and were agreeable companions on the hill. At the Loch the party divided so as to give the range of rocks a thorough inspection, but to reach the plateau most of the members had to come to the south side and ascend by a very steep watercourse, as the rocks farther round could not be climbed with safety. *Woodsia hyperborea*, Br., is said to grow on the higher ledges, but this plant was certainly not obtained by any of us. However, plenty of *Asplenium viride*, Huds., and *Aspidium Lonchitis*, Sw., were growing in the rock crevices; while *Hieracia*, Mountain Saxifrages, *Cochlearia alpina*, Wats., all in full flower, fringed the rocks, and made a very steep ascent more interesting than it otherwise would have been. It certainly was a work of time to attain the plateau, but it was much easier to ascend than to descend. On attaining the level a grand view was obtained of Schiehallion, Ben Lawers, Beinn Ghlas,—even to the Lomonds in Fife, with Benarty, and the more distant Pentlands and Moorfoots. The air was clear and the weather pleasant. We now found ourselves among bogs, rocks, and streamlets, with a line of precipices running in a southerly direction, the cone of Meall-nan-Tarmachan towering like a castle above us. Several of our men went to the summit, where Hooker states *Andreæa nivalis* is to be found. The summit of Ben Nevis would be a more certain station. The line of rocks previously alluded to looked very promising, being moist, the soil micaceous schist. This region is so accessible that many eminent botanists and competent rock-climbers have scoured every inch of these ledges. So much depends on

the particular season at which the locality is visited, that there is always a chance of picking up some new form or rare plant. Perhaps the best flowering plant which was gathered here was a lovely rose-pink form of *Veronica saxatilis*, L., with a deep ring of crimson round the base of the corolla. The plants grew in most inaccessible situations, and in no great abundance. With the assistance of our Killin companions we succeeded in gathering a few specimens which have grown freely on the rock border here. The plant seen growing in the moss (*Trichostomum lanuginosum*), and in full flower in its own native home was a singularly beautiful object. On the ledges were also gathered *Juncus castaneus*, L.; *J. biglumis*, L.; *Carex pulla*, Good.; *C. pallescens*, L.; *Veronica saxatilis*, L.; *Draba incana*, L.; *D. rupestris*, Br.; *Cerastium alpinum*, L.; *C. latifolium*, Sm.; *Potentilla Sibbaldia*, L.; *Thalictrum alpinum*, L.; *Potentilla salisburgensis*, Hænke, a very pretty plant with the brown spots at the base of the corolla. Other mountain forms of *Potentilla;* *Salix herbacea*, L.; *S. reticulata*, L.; *Trollius europæus*, L.; *Cochlearia alpina*, Wats., were curiously associated in this elevated region with *Viola lutea*, Huds., var. *amœna*, the petals of a bright blue colour. *Armeria vulgaris*, Willd.; and *Oxyria digyna*, Hill, also grew close together. *Saxifraga nivalis*, L., was sticking closely to the rock faces in full flower and in great abundance; while, in moist situations, *S. stellaris*, L.; *S. hypnoides*, L.; *S. aizoides*, L., flourished, fringing the rocks and showing its rose corollas. *S. oppositifolia*, L., hung in festoons from the rocks. *Lycopodium Selago*, L.; *L. alpinum*, L.; and *Selaginella selaginoides*, Gray, were observed in plenty. On the ledges, *Carex atrata*, L.; *C. capillaris*, L.; *C. pulla*, Good., were gathered in fine specimens. Mosses were in abundance, and the following were obtained: — *Splachnum mnioides*, *Conostomum boreale*, *Hypnum trifarium*, *Leskea rufescens*, *Andreæa alpina*, *Bryum Zierii*, and several other varieties, were gathered. The gentian station, where *Gentiana nivalis*, L., was plentiful at one time, was examined without result, but the season was too early for its flowering, and without the colour the plant is not easily found. Killin was reached after a long walk in time for a late dinner.

Thursday, 21st July.—The excursion to-day was to Creag-na-Caillich. The morning was dry and pleasant, and favourable for a mountain excursion. After passing Bridge of Lochay, the path by the side of the burn which comes from above was taken, in the fine old Finlarig woods, the last remains of the old Caledonian Forest. We followed the path till the heathery moors were reached. The inclination of the ground is very steep, there being many rocky interruptions, the path being in many places close to the edge, with the stream a hundred feet below, and requires careful walking—not just the place to come down in the dark. The open moor being reached, a long walk to the left has to be accomplished before the first series of rocks on Creag-na-Caillich are attained. We must confess that these rocks are rather disappointing to the botanist. So many persons go to them for the purpose of collecting, that very few rare plants are to be got there. We may mention here that, in passing Bridge of Lochay, a party of twenty ladies and gentlemen residing there, all of the botanical order, were holding a council of war in front of the hotel as to the locality they intended to visit that day. There need be no wonder that the rarer plants are scarce. However, by working up the corrie good ground still exists. It was only on the more elevated ledges near the head of the corrie that the undermentioned plants were found:—*Dryas octopetala*, L.; *Salix herbacea*, L.; *S. reticulata*, L.; *Silene acaulis*, L., var. *aurea*, and the ordinary form; *Veronica saxatilis*, L.; *Viola amœna*, very bright blue specimens; *Draba incana, L.*; *D. rupestris*, Br.; *Saxifraga nivalis*, L.; *Antennaria dioica*, Br.; very fine specimens of *Carex atrata*, L.; *C. rupestris*, All. (found by Mr. Boyd), and *C. pulla*, Good., were gathered; *Alisma ranunculoides*, L.; *Sagina Linnæi*, Presl.; etc. Among mosses, *Hypnum trifarium; H. scorpioides; Encalypta rhabdocarpa*, Schw.; *Conostomum boreale; Andreæa alpina; Grimmia spiralis*, H. et J.; and *Bryum Zierii*, Dicks., were among the best obtained. Several of our members went to the summit, which was quite clear of mist, and returned from the other side of the mountain to Killin.

Friday, 22nd July.—To-day the party divided. One division, consisting of Dr. Stuart, Captain Norman, and

Mr. Milne, set out to go to Cam Chreag, but, on reaching the place on the Kenmore road from which the ascent is usually made, a ferocious West Highland bull disputed our passage, and in consequence we lost "tracks," and "got off the line." Perhaps it was as well, as we have often been at Cam Chreag before, but never in the corrie of Ben Cruban, a mountain situated midway between Creag-na-Caillich and Meall-nan-Tarmachan. We had a most toilsome ascent to the rocks, which were not reached till after one o'clock. The hard walking of the previous days had, we suppose, told on our powers of locomotion in some degree. However, after a rest, a scramble among the ledges was undertaken, which were found to be well furnished with all the ordinary alpine plants. Although these rocks are not so extensive as those at Cam Chreag or Creag-na-Caillich, there is a far greater profusion of the alpines. One rock-face on the left side of the corrie, with a rough cleft in it from near the summit of the mountain, was about the most attractive rock garden we have seen for some time. Here flourished *Salix reticulata*, L.; *S. herbacea*, L.; *Dryas octopetala*, L.; *Veronica saxatilis*, L.; *Silene acaulis*, L., var. *aurea*, and the ordinary form in sheets of bloom, a beautiful sight at any time; *Saxifraga nivalis*, L., in great abundance and in fine flower; *S. aizoides*, L.; *S. hypnoides*, L.; *S. stellaris*, L., and *S. oppositifolia*, L., all in bright bloom. Several specimens of *Juncus biglumis*, L., were observed and left. *Draba rupestris*, Br., and *D. incana*, L., in both flower and fruit; *Cochlearia alpina*, Wats., *Cerastium alpinum*, L., and *C. latifolium*, Sm.; *Aspidium Lonchitis*, Sw.; *Asplenium viride*, Huds.; *Polypodium alpestre*, Hoppe, were more plentiful than in any other station. Many seedling forms of these and other ferns growing in the cracks of these rocks were very interesting to look at, but difficult to identify. Several Hieracia growing higher up in the cliffs were as yet not in flower. Although the walk to Ben Cruban is a very toilsome one from the boggy nature of the ground, the mountain is worthy of more careful exploration than we were able to give it with the time we had at command. The plants are mostly together, and easily collected.

The other division of the party, consisting of Messrs. Boyd, Paul, and Gunn, set out on a visit to Ben Lawers. Driving up to the Lawers Inn, they followed thence the old peat road to Lochan a' Chait. Leaving Mr. Boyd there to botanize on the rocks by which it is bounded, the others made their way to the summit, returning by the same route to pick up their companion. Many of the well-known plants characteristic of the hill were found, such as *Potentilla salisburgensis*, Hænke; *Saxifraga nivalis*, L.; *S. cernua*, L.; *Erigeron alpinum*, L.; *Myosotis alpestris*, Schmidt; *Carex pulla*, Good.; *Lycopodium alpinum*, var. *decipiens* (found by Mr. Boyd growing rather plentifully about 200 feet above Lochan a' Chait). Quantities of *Potamogeton prolongus*, Wulf., were found on the margin of the lake, cast up by the waves. But a more interesting plant than any of these—*Carex ustulata*, Wahl.—was found by Mr. Paul on one of the slopes of the hill that descend towards the loch. It was said to have been found in Scotland for the first time by Mr. George Don in 1810, on Ben Lawers, but its occurrence as a British plant had become generally discredited until it was rediscovered, as members of the Society know, in July 1885, by Mr. Brebner of Dundee, in the corrie of Ben Heasgarnich. It was again found in the same spot in considerable abundance in the following year, and was afterwards found in the neighbourhood by Mr. A. H. Evans. But the discovery of it this year gives more exact confirmation of Mr. Don's accuracy and trustworthiness, as showing that it still grows on the same hill on which he declared he found it. The best specimen gathered was sent to the Botanic Garden, and there seen by Prof. Blytt, of Christiania, who pronounced it to be, "without doubt," *Carex ustulata*.

Saturday, 23rd July.—The party left Killin this morning, at 7.15 A.M., and travelled *via* Stirling to Edinburgh, where the party separated for their respective homes, all greatly delighted with the excursion and sorry that it had come to an end.

On Lightning-Struck Trees at Methven Castle. By Prof. Bayley Balfour.

On Temperature and Vegetation in the Royal Botanic Garden, Edinburgh, during the month of November 1892. By Robert Lindsay, Curator of the Garden.

The past month of November was dull and gloomy, but somewhat mild for the season. Storms of wind and rain were less frequent than usual, and no snow fell during the month. The thermometer was at or below the freezing point on twelve mornings, indicating collectively 41° of frost for the month. The lowest readings were on the 1st, 27°; 2nd, 27°; 17th, 26°; 18th, 27°; 19th, 26°. The lowest day temperature was 39°, on the 16th, and the highest 57°, on the 11th. Very few plants are in flower, out-door vegetation being now almost dormant. Fruit has disappeared rapidly from most trees and shrubs, with the exception of holly, on which a good supply of berries still remain. On the rock-garden only two plants came into flower during the month, viz., *Helleborus altifolius* and *Gynerium argenteum*.

Readings of exposed Thermometer at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during November 1892.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	27°	34°	45°	16th	30°	33°	39°
2nd	27	32	44	17th	26	29	42
3rd	36	47	53	18th	27	29	41
4th	39	50	52	19th	26	35	45
5th	45	48	53	20th	34	42	48
6th	33	39	53	21st	40	42	44
7th	29	31	48	22nd	36	38	46
8th	35	46	53	23rd	38	39	44
9th	45	50	54	24th	29	35	45
10th	29	36	51	25th	33	37	44
11th	36	47	57	26th	32	44	46
12th	35	43	51	27th	32	46	53
13th	43	45	50	28th	43	49	53
14th	42	45	51	29th	35	36	45
15th	42	49	52	30th	28	30	40

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of November 1892.

Distance from Sea, 1 Mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Min.	Thermometers, protected, 4 feet above grass. Hygrometer. Dry.	Thermometers, protected, 4 feet above grass. Hygrometer. Wet.	Direction of Wind.	Clouds. Kind.	Clouds. Amount.	Clouds. Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·790	45·9	30·0	33·6	33·2	Calm.	Cir.	5	W.	0·000
2	29·636	41·3	30·7	33·4	32·7	E.	...	0	...	0·060
3	29·296	46·1	32·6	46·4	44·4	S.W.	Cir.	2	W.	0·010
4	29·422	51·0	42·0	50·1	48·5	S.	Nim.	10	S.	0·010
5	29·472	55·5	47·2	50·9	48·1	S.	Cum.	1	S.	0·000
6	29·730	55·5	36·2	41·3	41·0	W.	Cum.	10	W.	0·000
7	30·052	47·4	31·6	32·7	32·7	W.	...	0	...	0·110
8	29·923	47·5	31·9	47·7	46·8	S.W.	Nim.	10	S.W.	0·030
9	29·813	51·9	47·0	51·2	49·0	S.W.	Cir. St.	10	S.W.	0·050
10	29·960	52·9	31·8	35·1	35·0	W.	Cir.	4	W.	0·000
11	29·921	48·0	34·6	48·2	46·5	S.S.W.	Cum.	10	S.S.W.	0·000
12	29·850	54·6	38·1	44·7	43·0	W.	Cum.	8	S.W.	0·060
13	29·561	49·0	44·0	47·3	47·0	S.	Nim.	10	S.	0·010
14	29·556	47·8	40·0	43·8	41·8	S.E.	Nim.	10	S.	0·170
15	29·436	55·5	43·0	48·8	47·9	W.	Cum.	10	W.	0·000
16	29·728	50·7	32·8	34·8	34·9	W.	Cir.	6	S.W.	0·000
17	29·920	42·8	28·9	30·2	30·0	Calm.	Cir.	4	S.W.	0·000
18	29·791	41·0	29·3	30·8	30·8	W.	Fog	10	...	0·000
19	29·608	40·2	29·5	36·2	34·0	E.	Cir. Cum.	5	S.	0·040
20	29·895	42·6	35·7	42·7	41·0	S.E.	Cum.	10	S.E.	0·030
21	30·268	47·0	42·0	42·9	42·7	S.E.	Nim.	10	S.E.	0·000
22	30·345	44·1	39·4	40·1	39·0	S.E.	Cir	3	N.W.	0·000
23	30·260	44·9	39·9	40·6	38·0	S.E.	Cum.	9	S.E.	0·000
24	30·105	40·8	31·1	36·7	35·2	Var.	Cum.	10	W.	0·000
25	30·149	39·5	36·0	38·7	37·1	S.E.	Cir.	5	S.E.	0·230
26	29·807	45·3	35·5	45·2	44·7	S.W.	Nim.	10	S.W.	0·240
27	30·086	46·6	35·8	46·6	45·7	S.W.	Cum.	10	S.W.	0·000
28	30·000	51·8	46·1	50·0	47·3	W.	Cum.	5	W.	0·140
29	29·694	52·8	37·1	37·7	36·3	S.W.	...	0	...	0·170
30	29·855	41·9	30·5	32·0	30·6	W.N.W.	...	0	...	0·110

Barometer.—Highest Reading, on the 22nd, =30·345. Lowest Reading, on the 4th, = 29·422. Difference, or Monthly Range, = 0·923. Mean = 29·831.

S. R. Thermometers.—Highest Readings, on the 5th, 6th, and 15th, = 55°·5 Lowest Reading, on the 17th, = 28°·9. Difference, or Monthly Range, = 26°·6 Mean of all the Highest = 47°·4. Mean of all the Lowest 36°·3. Difference, or Mean Daily Range, = 11°·1. Mean Temperature of Month = 41°·8.

Hygrometer.—Mean of Dry Bulb = 41°·3. Mean of Wet Bulb = 40°·2.

Rainfall.—Number of Days on which Rain, or Snow, fell = 16. Amount of Fall in inches, = 1·470. First Fall of Snow for season on night of 30th.

A. D. RICHARDSON,
Observer.

MEETING OF THE SOCIETY,

Thursday, January 12, 1893.

Dr. DAVID CHRISTISON, President, in the Chair.

Professor JOHN STRUTHERS, M.D., LL.D., was elected Resident Fellow of the Society.

Presents to the Library at the Royal Botanic Garden were announced.

In accordance with notice duly given, Dr. WILLIAM CRAIG brought forward his proposal for the amendment of the Laws of the Society with the purpose of admitting Ladies to full Membership of the Society on the same terms as Gentlemen. He moved as follows:—

> That Article 3, Chapter I. of the Laws of the Society be repealed, and the following article substituted therefor:—
>
> "3. The Society shall be open to Ladies and Gentlemen, and shall consist of Honorary, Resident, Non-Resident, Foreign, and Corresponding Members, who shall have the privilege of denominating themselves Fellows of the Society; of Lady Members elected under the Rule, Chapter IV., Section VI. hereof; and of Associates elected under the Rule, Chapter IV., Section V. hereof."
>
> That the following words be added to the Rule, Chapter IV., Section V., relating to Associates, viz.:—"are not entitled to receive copies of the Transactions, and have no interest in the property of the Society."
>
> That the following words be added to the Rule, Chapter IV., Section VI., relating to Lady Members, viz.:—"or may be elected and continue a Member on payment annually of a Subscription of 10s.; but Lady Members, elected under this rule, shall not be entitled to receive copies of the Transactions, shall have no voice in the management of the Society, nor any interest in the property thereof."

Mr. WILLIAM MURRAY seconded the motion, which was unanimously adopted by the Society.

The CURATOR exhibited from the Royal Botanic Garden a plant of the aroid *Nephthytis liberica*, introduced in 1881 from Liberia, by Mr. Bull; a plant of the "caraguata ue" of the natives of Paraguay, a bromeliad, grown from

seed brought by Mr. Graham Kerr, naturalist with the Pilcomayo Expedition; and a twig of *Thuya orientalis*, showing russet brown tints in winter which in summer are replaced by a golden hue.

Dr. JOHN WILSON sent for exhibition fruits of *Celastrus scandens*, the bitter-sweet of America, brought from Minnesota by Mr. J. Orr.

Professor BAYLEY BALFOUR exhibited a branch of *Abies nobilis*, sent by Sir James Gibson Craig, of Riccarton, showing tubercular growth of the cortex; also a set of cultures of microphyta, prepared by Dr. Krahl, of Prag, in a form said to be permanent and in which they could be shown in a museum.

Dr. CHRISTISON exhibited a photograph of a tree said to be the largest in Victoria, and measuring 57 feet in girth and about 450 in height; also a panel about 3 feet square, veneered on both faces with walnut of high quality, obtained from a large tree grown at Otterstone, Fife. The tree was 15 feet in girth, and was supposed to be 300 years old. Dr. Christison presented the panel to the Museum of the Royal Botanic Garden as an example of the best walnut wood ever grown in Scotland.

The following Communications were read:—

DESCRIPTIONS OF PLANTS COLLECTED DURING THE PILCOMAYO EXPEDITION. By J. GRAHAM KERR.

NOTE ON THE ROOTS OF PLANTS GROWN IN TUBS IN THE ROYAL BOTANIC GARDEN. By Professor BAYLEY BALFOUR.

ON TEMPERATURE AND VEGETATION IN THE ROYAL BOTANIC GARDEN, EDINBURGH, during the month of DECEMBER 1892. By ROBERT LINDSAY, Curator of the Garden.

The weather of the past month was of an exceedingly wintry character. Frost was registered on twenty-three mornings, indicating collectively 192° of frost for the

month. So much frost has not been registered at the garden for December since 1879. During the corresponding month of 1891, frost was registered on eighteen mornings, the total amount being 83° only. The lowest readings of the thermometer for the last month occurred on the 3rd, 16°; 4th, 16°; 25th, 15°; 26th, 12°; 27th, 13°. The lowest day temperature was 24°, which occurred on the 25th of the month, and the highest 56°, on the 18th.

On the rock-garden only one plant came into flower, namely, *Primula inflata.* A special feature is the deep russet-brown tints of the foliage of the varieties of *Thuya orientalis,* which on the south side of the plants is much more pronounced than on the north, giving them a very curious appearance. During summer the brown tints disappear, and assume a golden colour. The total number of species and well-marked varieties which have flowered on the rock-garden during the year 1892 amounts to 1211, as against 1216 for 1891. The largest number came into bloom during the month of June. A record has been kept, showing the date when each plant was first observed in flower. The number of species which came into flower each month was as follows:—January, 7; February, 31; March, 39; April, 119; May, 282; June, 330; July, 237; August, 103; September, 45; October, 15; November, 2; December, 1:—total, 1211.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during December 1892.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	29°	32°	35°	17th	37°	39°	42
2nd	16	17	35	18th	45	49	56
3rd	16	33	43	19th	42	41	46
4th	25	26	36	20th	35	36	41
5th	22	23	39	21st	35	37	42
6th	22	34	40	22nd	36	39	41
7th	27	29	35	23rd	27	28	38
8th	23	29	36	24th	24	26	38
9th	27	29	34	25th	15	18	24
10th	27	30	41	26th	12	19	29
11th	32	34	43	27th	13	19	42
12th	31	34	40	28th	24	26	40
13th	27	32	45	29th	26	38	42
14th	26	41	45	30th	24	25	36
15th	36	41	46	31st	19	30	35
16th	35	37	49				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of December 1892.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass.				Direction of Wind.	Clouds.			Rainfall. (Inches.)
		S. R. Thermometers for preceding 24 hours.		Hygrometer.						
		Max.	Min.	Dry.	Wet.		Kind.	Amount.	Direction.	
		°	°	°	°					
1	29·718	36·8	31·4	33·2	33·0	S.E.	Nim.	10	S.E.	0·080
2	30·065	34·8	18·2	19·7	19·0	W.	...	0	...	0·080
3	29·370	34·0	18·8	34·1	34·1	Var.	Nim.	10	W.S.W.	0·010
4	29·374	39·9	25·9	26·7	25·8	W.	...	0	...	0·000
5	29·511	30·9	24·1	25·1	23·6	W.	...	0	...	0·000
6	29·610	35·4	24·2	35·8	34·1	W.	Cum.	8	N.N.W.	0·160
7	30·095	38·8	31·0	32·1	31·9	N.E.	Cum.	8	N.E.	0·000
8	30·113	32·9	27·0	29·8	29·0	S.W.	Cum.	2	N.W.	0·240
9	29·819	35·0	29·1	31·6	29·8	N.N.W.	...	0	...	0·000
10	29·784	33·0	24·2	33·2	33·1	S.W.	St.	10	S.W.	0·120
11	29·070	42·1	32·6	37·1	36·4	S.W.	Cum.	10	S.W.	0·010
12	29·252	40·2	36·2	36·8	35·1	W.	Cir.	5	W.	0·000
13	29·771	38·6	29·9	34·3	31·1	W.	Cir.	1	N.W.	0·100
14	29·611	43·9	28·6	43·2	45·1	S.W.	Nim.	10	S.W.	0·070
15	29·696	44·6	38·3	43·0	42·0	W.	Cum.	10	W.	0·000
16	30·025	45·2	36·0	37·7	37·7	W.	Cir. St.	10	W.	0·060
17	29·836	51·0	36·9	46·0	44·2	S.W.	...	0	...	0·020
18	29·749	53·6	45·8	48·1	45·4	W.	...	0	...	0·000
19	29·907	48·7	44·0	45·7	45·0	W.	Nim.	10	W.	0·160
20	29·988	46·7	37·7	38·2	38·0	E.	Nim.	10	E.	0·001
21	29·974	40·2	37·4	39·2	39·1	Calm	Cum.	10	S.E.	0·001
22	29·959	41·1	38·0	40·1	39·1	Calm.	Cum.	10	N.E.	0·000
23	30·059	41·9	30·1	30·8	29·8	E.	Fog.	10	...	0·000
24	29·941	36·9	27·0	28·0	27·0	S.E.	...	0	...	0·000
25	29·871	30·8	18·2	20·8	19·7	W.	Fog.	10	...	0·000
26	30·046	23·5	15·1	19·2	19·1	W.	...	0	...	0·000
27	30·146	28·1	18·8	21·2	21·1	W.	...	0	...	0·000
28	30·106	31·9	20·4	29·9	29·8	W.	...	0	...	0·000
29	29·788	39·5	29·0	39·7	38·8	S.W.	Cum.	10	S.W.	0·000
30	29·704	40·8	28·6	29·3	28·6	W.	...	0	...	0·000
31	29·847	33·3	21·9	30·0	29·0	Var.	Nim.	10	S.	0·010

Barometer.—Highest Reading, on the 27th, = 30·146. Lowest Reading, on the 11th, = 29·070. Difference, or Monthly Range, = 1·076. Mean = 29·800.

S. R. Thermometers.—Highest Reading, on the 18th, = 53°·6. Lowest Reading, on the 26th, = 15°·1. Difference, or Monthly Range, = 38°·5. Mean of all the Highest = 38°·5. Mean of all the Lowest = 29°·2. Difference, or Mean Daily Range, = 9°·3. Mean Temperature of Month = 33°·8.

Hygrometer.—Mean of Dry Bulb = 33°·5. Mean of Wet Bulb = 32°·7.

Rainfall.—Number of Days on which Rain, or Snow, fell = 15. Amount of Fall, in inches, = 1·122.

A. D. RICHARDSON,
Observer.

Abstract of Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during 1892.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-level, 71·5 feet. Hour of Observation, 9 A.M.

Months.	Barometer, corrected and reduced to 32°. (Inches.)						Thermometers, protected, 4 feet above grass.												Rain, etc. (Inches.)			
							Self-Registering Thermometers.										Hygrometer.					
	Highest.		Lowest.		Range	Mean.	Highest.		Lowest.		Range	Mean of all the Highest.	Mean of all the Lowest.	Mean Daily Range.	Mean Temperature.	Mean of Dry Bulb.	Mean of Wet Bulb.	No. of Days on which Rain, etc., fell	Amount.	Greatest Fall in 24 Hours.	
	Date.	Reading.	Date.	Reading.			Date.	Reading.	Date.	Reading.										Date.	Amount
January, . .	25	30·218	6	29·056	1·162	29·656	30	54°·5	8	23°·0	31°·5	40°·6	30°·8	9°·8	35°·7	35°·5	34°·0	19	0·937	18	0·225
February, . .	13	30·533	2	28·765	1·769	29·669	13	51·4	19	8·4	43·0	42·0	31·9	10·1	36·9	36·0	34·8	24	1·891	14	0·545
March, . .	22	30·520	13	29·322	1·198	29·967	19	60·6	28	19·2	41·4	43·5	31·2	12·3	37·4	36·9	34·5	11	1·175	26	0·390
April, . .	1	30·375	27	29·399	0·976	29·935	3	66·8	17	24·2	42·6	51·8	34·9	16·9	43·4	43·9	40·3	13	1·055	27	0·380
May, . . .	12	30·390	16	29·267	1·123	29·842	31	68·8	2	31·8	37·0	58·2	42·6	15·6	50·4	51·7	48·2	20	2·795	22	0·500
June, . . .	8	30·288	2	29·372	0·916	29·850	10	80·6	13	36·8	43·8	62·2	46·4	15·8	54·3	55·2	51·2	20	2·900	19	0·465
July, . . .	27	30·290	7	29·108	1·182	29·905	31	70·0	21	41·6	28·4	62·6	49·4	13·2	56·0	56·0	52·9	12	0·990	18	0·310
August, . .	10	30·127	31	29·202	0·925	29·716	23	72·5	10	39·8	32·7	65·1	50·4	14·7	57·7	58·9	55·1	21	4·645	29	0·810
September, .	22	30·176	27	29·141	0·816	29·653	14	65·1	30	38·2	26·9	58·9	45·9	13·0	52·4	53·7	50·6	19	1·089	23	0·198
October, . .	18	30·273	9	28·764	1·509	29·637	29	58·0	25	23·0	35·0	49·2	37·3	11·9	43·2	43·0	41·3	23	3·450	3	0·945
November, .	22	30·345	4	29·422	0·923	29·831	5, 6, 15	55·5	17	28·9	26·6	47·4	36·3	11·1	41·8	41·3	40·2	16	1·470	26	0·240
December, . .	27	30·146	11	29·070	1·076	29·800	18	53·6	26	15·1	38·5	38·5	29·2	9·3	33·8	33·5	32·7	15	1·122	8	0·240
For Year, . .	Feb. 13	30·533	Oct. 18	28·764	1·769	29·788	June 10	80·6	Feb. 19	8·4	72·2	51·7	38·8	12·8	45·2	45·5	43·0	213	23·519	Oct. 3	0·945

NOTE.—Owing to an error in the graduation of the measuring glass used during 1891, the Total Rainfall for that year was understated in the Abstract by 1·430 inch. The correction to be applied is + 0·060 inch per inch of fall.

A. D. RICHARDSON, } *Observers.*
A. ANDERSON, }

MEETING OF THE SOCIETY,

Thursday, February 9, 1893.

Dr. DAVID CHRISTISON, President, in the Chair.

Dr. LEO ERRERA, Professor of Botany in the University, Brussels, and Dr. FR. SCHMITZ, Professor of Botany in the University and Director of the Botanic Garden, Greifswald, were, on the recommendation of the Council, chosen Corresponding Fellows of the Society.

Presents to the Library at the Royal Botanic Garden were announced, amongst these being a number of papers relating to the foundation of the Society, given by Commander A. F. Balfour, R.N.

The TREASURER submitted the following Statement of Accounts for the Session 1891–92:—

RECEIPTS.

Annual Subscriptions, 1891–92, 71 at 15s.,	£53	5	0
Do. do., 1890–91, 2 at do.	1	10	0
Compositions for Life Membership,	12	12	0
Transactions, etc., sold,	6	19	1½
Diplomas, Fees,	0	14	5
Interest received,	1	7	6
Subscriptions to Illustration Fund,	11	1	0
Receipts,	£87	9	0½
Balance of Payments,	33	12	0
	£121	1	0½

PAYMENTS.

Printing Transactions, £63, 6s. 7d.; Billets, etc., £7, 19s. 4d.,	£71	5	11
Lithographing and Engraving,	13	14	6
Assistant Secretary's Salary,	15	0	0
Diploma Boxes, and Stamping Diplomas,	1	2	3
Rooms for Meetings, and Tea,	6	19	8
Commission paid to Collector,	1	7	9
Postages, Carriages, etc.,	11	3	10½
Sundries,	0	7	1
Payments,	£121	1	0½

Issued November 1893.

STATE OF FUNDS.

Amount of Funds at close of Session 1890–91, . .		£69 14 2
Decrease during Session 1891–92, ...		33 12 0
Amount of Funds at close of Session 1891–92, . .		£36 2 2
Being:—Sum on Current Account with Union Bank of Scotland, . .	£36 1 7	
Balance in hands of Treasurer, . .	0 0 7	
		36 2 2

EDINBURGH, 31*st January* 1893.—Certified as a correct Abstract of the Treasurer's Accounts, which have been audited by me, compared with the Vouchers, and found correct.

ROB. C. MILLAR, C.A., *Auditor.*

The TREASURER intimated the receipt since last meeting of the following subscriptions to the Illustration Fund:—

Dr. Christison, ...	£2 2 0
William Sanderson, Esq., . .	1 1 0
Dr. Cleghorn, ...	1 0 0
John Clayton, Esq., *per* Dr. Christison, . . .	0 10 6

The attention of Members of the Society was directed by Dr. William Craig to the following appeal on behalf of the Illustration Fund which the Council had issued:—

THE ILLUSTRATION FUND.

This important Fund was commenced eighteen years ago, and the total contributions have amounted to £178, 4s. 6d.

During the same period the Society has spent on Illustrations £198, 19s. 1d., being £20, 14s. 7d. more than the sums received.

The above statement brings down the state of the Illustration Fund only to the beginning of the present Session.

From these figures it is evident that the *Transactions* could not have been illustrated as they have been but for the existence of this Fund.

The Council would therefore respectfully appeal to the Members of the Society to contribute to this Fund, so that in the future, as in the past, the papers published in the *Transactions* may be illustrated in a manner worthy of the Papers and of the Society.

The CURATOR exhibited plants of *Saxifraga Burseriana*, *S. Burseriana multiflora*, *S. imbricata*, *Crocus chrysantha*, *Iris stylosa*; and twigs of *Garrya elliptica*, *Hamamelis japonica*, and *Jasminum nudiflorum* in flower, from the Royal Botanic Garden.

Mr. LINDSAY exhibited twigs of *Ulmus campestris* showing remarkable development of cork, sent by Mrs. Astell, of Dorchester; also a branch of *Pinus sylvestris* from Blair-Athole, showing an excess in number of cones, sent by Mr. J. G. Thomson, 71 South Clerk Street.

Dr. WILLIAM CRAIG exhibited a print of *Ipomœa tuberosa* found on the shore of South Ireland, and sent by Mr. Beemish of Cork.

Professor BAYLEY BALFOUR exhibited a portion of a stem of laburnum which, being rotted in the centre, had given passage to an ivy stem entering through some aperture, and the ivy stem now filled the pith cavity of the laburnum. The specimen was sent by Mr. T. M. Callendar, Inverard.

The following Papers were read:—

NOTES ON THE MORPHOLOGY OF SOME BRITISH LEGUMINOSÆ. By JAMES A. TERRAS, B.Sc.

I have in the following notes given a summary of some general points of Morphology exhibited by the British Leguminosæ, and have subsequently referred particularly to the morphology of *Ulex europæus*. The known facts regarding the morphology of our British plants is so widely scattered, mostly in foreign literature, that the sweeping together of what is known, along with the communication of fresh facts, will, it is hoped, be of interest to those who are interested in our native flora. In later communications I shall hope to deal with other species of the family.

SEED.—The seeds of the British species of Leguminosæ are usually of moderate size, varying from about 1 mm. to 5 or 6 mm. in length, their breadth, measured across the cotyledons and radicle at their widest part, is somewhat less, while their thickness may be similar to their breadth, but is generally somewhat smaller, and may in many cases be taken as half of the height or thereabout. As regards colour, all gradations of tint between pale yellow and a deep reddish purple black may be observed.

The embryo is curved; the cotyledons, closely applied to one another by their upper surfaces, enclose between them the minute rudiments of the plumule; while the radicle, curving backwards, runs for a greater or less distance along their edges, either parallel to these or projecting slightly outwards so as to form an angle with the median plane of the cotyledons.

The seed is borne at the free end of a short funicle, and when ripe, is set free in such a way that the funicle is left behind attached to the placenta. The separation between the seed and the funicle takes place by two distinct methods; either all the funicular tissue is detached from the seed, and this is by far the commoner mode, or a definite part of the funicle is left attached to it in the form of a false aril. In the former case a scar, generally of a different colour from the rest of the seed-coat, is left on that part of the seed to which the funicle was attached.

This scar, which is called by Nobbe (V.) the hilum, is often a mere point, usually somewhat sunk in the seed-coat, and lying in the hollow between the cotyledons and the apex of the radicle. It is, however, often elongated, taking a somewhat elliptical form and extending more or less round the end of the cotyledonary part of the seed—*i.e.*, over the apex of the cotyledons. Moreover, it not unfrequently becomes a mere linear mark extending along the edge of the cotyledons towards that part of the seed which corresponds to their base. In the unripe seed it is covered by a similarly shaped mass of parenchymatous tissue, formed as an outgrowth from the apex of the funicle and more or less triangular in transverse section.

The free part of the funicle does not, however, arise from the middle of this outgrowth, but is in most cases united to it at no great distance from the end next the micropyle. A vascular bundle runs up the funicle and along the outer edge of this parenchymatous tissue, till it reaches the end of the scar remote from the radicle, and there enters the seed.

In the case of these seeds which possess a false aril, the tissue at the apex of the funicle forms a short, thick mass, covering a small, elliptical, rather deeply sunk scar. The outer layers of this funicular tissue are composed of

moderately thickened cells, which grow out on each side of the funicle, so as to form two lateral fan-shaped structures, which diverge from one another in the direction of the radicle, but generally fuse at the end next the cotyledons. In this way the funicle appears to spring from the central part of the tissue at its apex between two divergent plates of somewhat thickened cells.

This central tissue, of which the free part of the funicle is a continuation, is composed of very thin-walled cells, which, when the seed is ripe, give way along the plane at which the two lateral wings are given off, leaving the seed attached to its funicle by the bundle alone, or together with a small remanent of thin-walled tissue on one side.—Comp. Bachmann (I.). When the bundle breaks, which happens as soon as the seed is dry enough, the seed is set free, and the lateral wing-like expansions adhere to it forming the false aril.

Round the edge of the seed at a little distance from that end of the hilum at which the vascular bundle from the funicle enters the seed-coat, we find a not very distinct wart-like protuberance on the surface. This is described and figured by Schleiden and Vogel (VI.) as the "Chalaza," that is to say, the point at which the vascular bundle enters the nucellus. Sempolowski (VII.) follows Schleiden in calling this region the "Chalaza." But Mattirolo and Buscalioni (IV.), who describe here a pair of protuberances placed one on each side of the middle line, apply to these the name "tubercoli Gemini," and seem, as far as can be determined from an abstract of their work, which appeared in the *Botanische Centralblat*, and on which I am dependent for my information, not having yet seen the original paper, to deny that this region corresponds to the Chalaza, stating, what is certainly a fact, that the vascular bundle does not enter the seed-coat at this point. As I have not yet seen my way to study the development of these seeds, I am unable at present to state whether the funicular bundle enters the nucellus at a point corresponding to these tubercules or not.

As regards the tubercules themselves, they are easily recognisable in the majority of seeds, and appear to the unaided vision as a slight elevation of a somewhat darker

colour than the rest of the seed-coat; the double character of this elevation is easily made out by means of a hand lens, the two tubercules being somewhat darker in colour than the median line which divides them.

GERMINATION.—As soon as the seed is placed in damp soil, it commences to swell, owing to the absorption of water in considerable quantities, through the whole surface of the seed-coat, but specially through the hilum. The time required for complete saturation varies in different species, and also in different individuals of the same species, though, in the latter case, the great majority of the seeds contained in any one sample will become saturated in about the same time.

Detmer (III.) found that out of 1000 seeds of *Trifolium pratense* placed in water, 919 were completely saturated in one day, while at the end of ten days only 25 more were fully swollen, and after 156 days 30 seeds in one experiment and 10 in another remained still unaffected. According to the observations of Bruying (II.), a still larger percentage of the seeds remain hard in the case of *Ulex europæus.* In this plant only 4·7 per cent. had germinated after six days, while at the end of fourteen days 30·2 per cent. showed signs of growth, leaving a very large percentage of "hard" seeds.

Various methods, having for their object the obtaining of a higher germination percentage, were tried by this author—the seeds were treated with sulphuric acid of various strengths, with solutions of soda, etc., but the best results were obtained by mechanical abrasion of the seed coat by means of sharp sand; seed so treated gave a germination percentage of 30·2 after six days, and of 63·5 after fourteen days.

As soon as sufficient water has been absorbed growth commences in the embryo, and this, aided by the swelling of the inner layers immediately around the embryo, "Schleim endosperm," causes the rupture of the hard outer wall. As the radicle is the part in which growth first appears, it is usually in its neighbourhood that the seed-coat splits, and in most cases the split, commencing near the tip of the radicle, extends transversely on each side of it, passing round the sides of the seed.

In the majority of cases the radicle grows vertically downwards, branching slightly if at all, and generally reaches a considerable length, often several inches, before any further changes take place in the other organs of the embryo, and this is especially the case in those species which have hypogeal cotyledons. If, however, the cotyledons are to be epigeal, these are soon drawn out of the seed-coat by the elongation of the hypocotyl. In the seed this part of the axis, lying between the cotyledonary node and the radicle, is very short, but when elongation is about to take place in it intercalary growth is set up; and since, on account of the curved nature of the embryo, neither extremity can be moved, both the root and the apex of the cotyledonary part being pressed firmly against the soil in a downward direction, the hypocotyl is forced by its own elongation to assume the position and form of an inverted U, one limb of which, that attached to the radicle, is longer than the other. As it increases in length the curved part of the U approaches the surface of the soil, and not unfrequently appears above it.

Very soon, however, it commences to straighten itself out, and in the earlier stages of this process generally forms a sickle-like bend on that part of the longer limb where it is just passing over into the curve of the U, this bend being directed away from the cotyledons and so formed as to gain sufficient leverage to remove these from the seed-coat and raise them, edge first, through the soil.

As soon as the straightening of the hypocotyl is completed, the cotyledons, which till now have been closely applied to one another by their upper faces, and have not unfrequently retained on their apices the remains of the seed-coat as a small brown cap, separate from one another and become horizontally expanded at no great distance above the ground.

They are always green, and not unfrequently provided with a small petiole, the base of which expands into a sheathing vagina half surrounding the axis and uniting in many cases with that of the opposite cotyledon to form a short tube inclosing and protecting the plumular bud.

The cotyledonary lamina is generally entire, more or less broadly elliptical, though in *Hippocrepis* almost strap-

shaped, fleshy, and not unfrequently asymmetrical about its median line, being in these cases markedly concave near the base on one lateral margin, while the opposite one is as markedly convex at the same point. This want of symmetry, though very distinct in most of the species of *Medicago* and in *Onolrychis,* is not by any means of constant occurrence, and seems to be determined in great part, if not entirely, by the form of the seed, which, in its turn, may well depend on the exigencies of carpel formation.

In those genera where the cotyledons are hypogeal the first part to appear above ground is the plumule. This structure lies, in the seed, between the two cotyledons, but as germination proceeds it is drawn out from this position, on the one hand by the elongation of its own lower internodes, and on the other by the growth of the cotyledonary petioles, whereby the cotyledons are removed to a greater distance from the axis than before. As the young bud leaves the seed the apex is found in most cases to be more or less closely bent down towards the base, so that here again the two parts form an inverted U. In some cases the bend joining the two limbs is very sharp, and the two parts of the plumule are consequently very closely applied to one another. As the plumule increases in length, this bend, though gradually becoming opener, does not straighten out, and neither does any elongation take place in the apical part till the apex itself is raised quite clear of the surface by the elongation of the basal part, so that the delicate plumular bud is protected from injury, being drawn through the soil backwards by the elongation of what is practically the first plumular internode, the first leaf being generally borne somewhere near the bend.

The first plumular leaf arises typically in a plane placed at right angles to that of the two cotyledons, and in those genera which have these hypogeal it is placed on the side of the axis opposite to that on which the seed lies. It is generally, but not by any means always, simpler in character than are the adult foliage leaves, being frequently composed of but one leaflet if the older leaves have three, or of three if the older ones have a multifoliolate pinnate arrangement, though even in these latter, as in *Onolrychis,* it is not unfrequently unifoliolate.

In most cases the adult form is not reached till a considerable number, often four or five leaves of an intermediate nature, have appeared; and in some cases, where the adult form is highly specialised, as in *Ulex*, several distinct series of leaf-forms arise in succession before the permanent condition is attained.

Those genera, such as *Vicia* and *Lathyrus*, which have hypogeal cotyledons almost always have the first leaf at least, and often the first two or three, reduced to mere scale-like organs, representing apparently the vaginæ of normal leaves, since three teeth are always discernable, and all gradations may be observed between the lateral teeth and the stipules of the adult leaves, while the median tooth passes over gradually, but not so distinctly, into the petiole of the higher form.

In genera with epigeal cotyledons the first leaf has, in many cases, a rather large lamina, which, borne on a long, slender, nearly vertical petiole, projects upwards above surrounding objects, and thus secures both light and air. The petiole is generally provided with a sheathing vagina, the margins of which are continued upwards into a pair of delicate stipules, which are, however, not of exactly the same shape, and not perhaps so highly specialised as those attached to the adult form of leaf.

Where the first leaf arises on an undeveloped first internode within a tubular sheath formed by the union of the cotyledonary vaginæ, it not unfrequently happens that the thickening of the plumular bud, consequent on its formation, splits the sheath along a line corresponding to the median plane of the leaf, and the two cotyledons, which lay at first opposite each other in a plane at right angles to that containing the first leaf, are forced to converge towards one another on the side opposite that from which the first leaf springs. This, however, cannot occur if the first internode be even slightly elongated, so as to raise the first node above the vaginal sheath.

STEM. — The aerial stem in most of the British Leguminosæ is annual, dying down in autumn to the level of the ground, and being replaced in spring, if the plant persists for more than one year, by a larger or smaller number of lateral branches, which arise from the subterranean part of the stem.

These lateral branches are, in many species, employed not only to reproduce the aerial part of the plant, with its leaves and flowers; but, having their origin below the soil, they may, instead of becoming aerial, remain subterranean, and running through the ground to greater or less distances from the parent, may give rise to new plants, which will ultimately become free by their death, and decay.

It is in this way, rather than by seeding, that the large circular patches of such sand-loving plants as *Astragalus hypoglottis, Ononis arvensis, Lotus corniculatus, and Lathyrus tuberosus,* which may be seen on almost any of our links during summer, are formed. The parent plant, generally situated near the centre of the group, is provided with a long tap-root often penetrating several feet into the soft sandy soil, and is generally connected till very late in life by means of the stout cord-like subterranean branches with the daughter-plants of the next generation, each of which has a similar but shorter tap-root, in this case of course adventitious, and is connected by a similar series of cords with a smaller circle of still younger plants, each with a small slender tap-root of its own, formed apparently from one of the nodes of the underground branch on which it is borne.

BRANCHING.—The branching of the aerial part of the primary stem, as well as that of the aerial parts of the branches just described, depends in many cases to a considerable extent on the formation of, so called, accessory, or as Wydler (VIII.) prefers to name them, serial buds which arise singly or in vertical median rows, the number in each being dependent on the strength of the plant. These rows are intercalated between the normal branch and the leaf in the axil of which it arises, the members of each row appear successively in descending series, so that the highest below the normal branch is the first to show itself and is always the strongest. The members of a row, though appearing at first vertically above one another, soon show a zigzag arrangement, which is initiated by the highest of the series deviating either to right or to left of the vertical line, while the next lower bud assumes a position alternating with it, the third being under the

first, the fourth below the second, and so on throughout the series. The direction of the deviation from the vertical of the highest serial bud depends, as Wydler remarks, on the direction of the primary phyllotactic spiral: if this is to the right, then the deviation is to the right; if left, to the left.

The subterranean branches are produced singly or in similar series in the axils of either the cotyledons or the first plumular leaves, but remain quiescent during the first summer of the plant's existence, and only develope to any great extent in the spring of the following year. Some of them are consequently normal axillary buds arising in the axils of the cotyledons or first leaves, while others are, so called, accessory buds.

M. Russell states, with a good deal of reason, that these accessory buds are not adventitious structures, but are successive branches arising from one another, the highest serial bud being a branch of the normal axillary bud, while the second is a branch of the first, and so on throughout the series; the leaves, in the axils of which the various branches arise, remaining undeveloped, as do also the internodes between them.

LITERATURE.

I. Bachmann.—Biologische Bedeutung des Arillus einiger Leguminosen.—Berichte der Bot. Gesellschaft, Bd. III., 1885.

II. Bruyning.—Beitrage zur Kenntniss unserer Landbausamerein.—*Ulex europæus* Journal fur Landwertschaft, Berlin, 1893.

III. Detmer.—Vergleichende Physiologie des Keimungsprocesses der Samen, p. 59.

IV. Mattirolo è Buscalioni.—Ricerche anatomofisiologiche sui tegumenti seminali delle Papilionaceae. Memorie della R. Accademia delle Scienze di Torino.—Serie II., T. XLII., Bot. Centralblatt., Bd. LII., p. 155.

V. Nobbe.—Handbuch der Samenkunde, 1876.

VI. Schleiden und Vogel. — Entwicklungsgeschichte der Leguminosenbluthe.

VII. Sempolowski.—Beitrage zur Kenntniss des Baues der Samenschale.—Inaugural Dissertation, Leipzig.

VIII. Wydler. — Kleinere Beitrage zur Kenntniss einheimischer Gewächse.—Flora, 1860, p. 23.

I. Ulex europæus.

Seed.—The seed is ellipsoidal, and more or less laterally compressed as regards the cotyledonary part, while the radicle runs along the edges of the cotyledons for almost

their whole length either closely applied to them or projecting to a greater or less extent, especially at the lower end. In colour the seed is dark greenish brown with a slightly yellow tint, and its surface is smooth and shining.

The hilum is small, elliptical, and situated in the hollow between the apex of the radicle and that of the cotyledons. It is, however, almost entirely concealed by the aril, which is of a bright yellow colour, narrowly horse-shoe-like in shape, and so placed that the open end lies just immediately below the apex of the radicle.

According to my measurements the average size of the seeds is 2·5 mm. long × 2 mm. broad × 1·5 mm. thick, while Harz (III.) mentions 3 mm. × 2·5 mm. × 1·8 mm. for the corresponding dimensions, so that the relations existing between these three dimensions appear to be fairly constant, the seeds observed by Harz being merely somewhat larger than those which I was able to obtain.

COTYLEDONS.—The cotyledons are epigeal, and generally lie expanded horizontally at no great distance above the surface of the soil. They are small, thick, bluntly elliptical, quite symmetrical about their median plane, and nearly twice as long as broad. They vary in length and breadth between rather wide limits, but the approximate size of full grown cotyledons may be expressed by the numbers 7–9 mm. long × 4–5 mm. broad. Sir J. Lubbock (V.) mentions 8 mm. to 1·1 cm. × 4–6 mm. as the approximate size, while Buchenau gives 8 mm. × 5 mm. The upper surface is smooth, somewhat shining and dark green, while the under side is distinctly paler in colour. They are quite sessile, being attached to the axis by a sheathing base, which is, however, much narrower than the lamina, and does not unite laterally with the corresponding part of the opposite cotyledon to form a closed tube surrounding the plumule, though both sheaths are nearly vertical and their edges are in contact on each side of the bud but not united. The fold, due to this sheathing base, gives to the narrow part of the cotyledonary lamina near it the appearance of being concave on its upper, and convex on its under surface, and is besides continued up into the body of the cotyledon, as it bends outwards to assume the horizontal position, and is there represented by a shallow

median groove on the upper surface corresponding to a somewhat more distinct ridge below.

HYPOCOTYL.—The hypocotyl, on which the cotyledons are raised above the ground, is short, slender, and terete, of a pale green colour on the shaded side, but frequently tinted with red on the face turned towards the sun. Under normal conditions it reaches a length, according to Sir J. Lubbock, of 5 mm. or 1 cm.; but, if grown in a shaded situation or among grass, it may become much longer, frequently attaining a height of from 2 to $2\frac{1}{2}$ or 3 cm.

ROOT.—The end of the radicle in most cases grows vertically downwards, branching slightly, and forming a strong tap root. The lateral rootlets are given off in four rows, arranged in two double rows, one vertically below each cotyledon, and corresponding to one extremity of the diarch xylem strand, which lies in the plane of the cotyledons. The members of each double row diverge from one another at an angle of about 20°, while the angular distance between the two double rows is about 160°. The root of *Ulex* thus agrees, in this respect, with that of the other Genisteæ, and falls into Van Tieghem's binary division of roots.

Tubercules are formed on both main and lateral roots very early indeed in the life of the plant, but they seldom attain any large size.

PLUMULE.—The first few internodes of the plumular bud are, in the majority of cases, but slightly developed, with the consequence that the leaves springing from the corresponding nodes are crowded together immediately above the cotyledons. The first plumular leaf lies in a plane at right angles to that occupied by the cotyledons, and the second leaf is placed almost opposite the first, but slightly higher up. The angular divergence of $\frac{1}{2}$, indicated by the opposite position of the first pair of plumular leaves, passes over at the third or fourth leaf into one of $\frac{1}{3}$, which, after a very few turns, is converted into a divergence of $\frac{2}{5}$, and this finally becomes $\frac{3}{8}$ in the adult plant.

Many variations, however, occur; not unfrequently the $\frac{2}{5}$ spiral is omitted, and the $\frac{3}{8}$ follows directly on the $\frac{1}{3}$ arrangement.

The first one or two plumular leaves are, in typical seedlings, provided with a simple spathulate or elliptical lamina without a terminal spine, supported on a somewhat elongated petiole-like structure (flattened vertically from above downwards), which passes gradually over into the lamina at its apex, while its base expands into a small sheath without stipules. These leaves are seldom expanded in a flat and horizontal manner, but the lateral margins generally curve upwards, so as to make the upper surface take the form of a more or less narrow longitudinal groove, which is continued down the upper face of the flat petiole to the sheathing base.

The upper surface is generally glabrous, like that of the cotyledons, but the lower is, on the other hand, covered with long white hairs, as are also the edges. The second or third leaf, according as the first one or two are simple, is generally provided with a small lateral leaflet, placed on one side of the main leaf, at or near the junction of the lamina with the petiole. This lateral leaflet exactly reproduces the lamina of the terminal part, but is much smaller in size, and the whole does not differ from those already described, except by the presence of this lateral appendage. After the appearance of one or two of these transition forms, the leaf, generally the fifth, sixth, or seventh, is found to have an additional lateral leaflet placed on the opposite side, so that it is now a tripartite leaf, all the segments being of nearly the same size.

The leaflets are now quite covered with long soft hairs, even on the upper surface, which had hitherto remained smooth, and the hairs on the leaf margins are especially long.

A considerable number of leaves are of this tripartite form, and usually it extends as far as the tenth, twelfth, or even thirteenth leaf, the leaflets becoming gradually narrower in the higher leaves. Thereafter the lateral lobes begin to diminish in size, and finally one disappears leaving a long, linear, median part, the lamina of which is but slightly broader than the petiole, and terminates in a short soft spine, together with a small, almost linear, lateral lobe on one side.

This lateral structure disappears in the succeeding one

or two leaves, and a long, narrow, linear leaf is left which gradually narrows until no expansion at all remains and the leaf is represented by its midrib alone, terminating in a hard sharp spine when the adult spine leaf form is reached.

Variations from this type are of very frequent occurrence, and of these, perhaps, the most common is the entire absence of the simple leaves intercalated between the cotyledons and the tripartite leaves, these last following in this case directly on the cotyledons without the appearance of any transition forms. About fifty per cent. of the seedlings which I have examined show no trace of simple leaves between the cotyledons and the trifoliate leaves, but in other respects closely resemble the type, while the remaining fifty per cent. are typical.

A form, however, in which all the leaves appear to be spathulate is mentioned by Sir John Lubbock (V., p. 410). The same author describes another seedling in which the first two are "linear-oblong," the second pair are provided with one lateral leaflet each, the fifth leaf is spathulate, the sixth "trifoliolate," and the eighth and ninth each provided with a lateral leaflet, while the succeeding leaves are spathulate. In both these cases there has clearly been an increase in the number of the spathulate simple leaves at the expense of the trifoliolate form, but in both simple leaves follow directly on cotyledons.

In another plant described by the same author, the first six leaves were trifoliolate, the remainder up to the eleventh being simple, while in other two specimens described by him other modes of arrangement of the three kinds of leaves occur, such as the intercalation of a spathulate leaf between two bifoliate leaves, or between the zone of tripartite leaves following directly on the cotyledons and the succeeding bipartite leaves.

Hildebrand (IV.), while describing and figuring the successive leaf-forms of what I regard as the typical case, mentions that in some seedlings the first simple leaves are altogether omitted, the tripartite leaves following directly on the cotyledons. Winkler (VI.), on the other hand, inclines to the view that this occurs in the majority of cases, and is in fact typical, he having only observed one specimen in which the tripartite leaves were preceded by

simple structures. This difference, however, he explains by the remark that, while he conducted his observations on cultivated plants, those described by Hildebrand were wild.

Buchenau (I.), who seems to have employed wild plants in his researches, states that the first stem leaves are generally tripartite and very seldom simple.

BRANCHING.—No branches are formed during the first year in the axils of either the cotyledons or the first few plumular leaves, but the higher trifoliate leaves, and all leaf organs higher up the axis, bear in their axils spine-branches. These are the only branches which appear during the first year, but in the spring of the second year the cotyledons and lower leaves give rise to axillary branches of another kind which are not spine-structures, but are, on the other hand, indefinite as regards their growth. At the same time similar, but in this case accessory, indefinite branches arise higher up the stem between the spine-branches and the leaves from the axils of which they spring.

After the commencement of the second year, therefore, a plant of *Ulex* exhibits two distinct kinds of branches, viz.:—the spine-branches, which are all axillary structures arising in the axiles of the spine-leaves; and the indefinite branches, of which the lower three or four are axillary in the axils of the cotyledons and lower leaves, while the higher are accessory, arising immediately below the axillary spine-branches, *i.e.* between them and their axillant leaves.

LEAF ARRANGEMENT.—The arrangement of the leaves is not the same on both these branch systems, and the leaves themselves also differ in their form and texture at least in the early stages of both. The first leaf organs borne on the spine-branches are two lateral prophylls, which take the form of spine-leaves placed opposite each other. The third leaf is placed in the median plane posteriorly, and is, according to Wydler (VIII.), the first leaf of a $\frac{1}{3}$ emprosthrodromous spiral of which he has observed three cycles, the second alternating with the first, while the third is placed directly over it, though in some cases this third cycle is absent and is replaced by a $\frac{3}{8}$ spiral.

In other specimens he finds the $\frac{1}{3}$ spiral entirely absent, while the $\frac{3}{8}$ follows immediately on the two prophylls.

Each of the leaves borne on a spine-branch, the two prophylls included, bears in its axil a spine-branch with at least two prophyllate spine-leaves and frequently one or more higher leaves occupying positions similar to those assumed by the leaves on the first spine-branch.

The indefinite branches which arise as accessory structures below the spine-branches, or as axillary branches in the axils of the cotyledons and lower leaves, but which do not appear in either position till the beginning of the second year, bear, like the spine-branches, two lateral prophylls which are, however, not spine-leaves in this case but scale-leaves somewhat triangular in outline, very small, and borne close to the base of the branch. These are followed by two leaves placed almost above the prophylls, but in both cases rather nearer the axillant leaf. With the next, *i.e.* the third leaf, a $\frac{1}{3}$ left to right spiral commences, and it is so placed that the second leaf of the spiral, *i.e.* the fourth leaf on the branch after the prophylls, lies in the plane of the axillant leaf.

This $\frac{1}{3}$ spiral passes over gradually into a $\frac{3}{8}$ spiral in such a way that the sixth leaf, or thereabouts, of the $\frac{1}{3}$ spiral is placed posteriorly in the median plane, and is also the first leaf of the permanent $\frac{3}{8}$ spiral of the branch. The earlier leaves of these branches, unlike those of the spine-branches, are soft, more or less scale-like structures, but these are gradually replaced by spine-leaves as their distance from the base of the branch increases.

These spine-leaves, but not the earlier soft leaves of an indefinite branch, bear spine-branches in their axils, and in this, as well as the character of their leaves, these branches repeat to a certain extent the characteristics of the main stem.

Not unfrequently these so-called indefinite branches terminate abruptly in a spine, but even so, are in most cases much longer than the axillary spine-branches, though not so long as other indefinite branches which continue to grow for at least one entire season. The spine-branches, which arise on the main stem in the first season, and on the indefinite branches, which take origin below them, in the second season, bear, as has been mentioned above, spine-branches; but these, like the primary spine-branches

of which they are branches, bear, in the season following that in which they appear, accessory branches arising immediately below them, and similar in character to the indefinite branches above described as terminating in a spine.

According to Delbrouck (II.), the spine-branches of *Ulex* persist in the cultivated state of the plant, while those of *Prunus*, etc., disappear; and he draws the conclusion that the spines of *Ulex* are specially evolved organs of the plant, while those of *Prunus* are due to degeneration of branches which, under more favourable nutritive conditions, continue to grow in length.

As long as either the main stem or its branches remain green and bear leaves the surface is marked by eight longitudinal grooves, which run alternately with eight ridges along the stem, the latter terminating one at the base of each leaf, while a new ridge commences above the median plane of the same leaf and runs up the stem through eight internodes, the spiral being a $\frac{3}{8}$ one, till it reaches the under side of the base of the ninth leaf. All these ridges are covered with long soft hairs, both on their backs and along, at least, the upper part of their sloping sides.

In the autumn following that of the season in which any given branch is produced, the ridges, along with all the chlorophyll-containing tissue, are cut off by means of a phellogen formation, which takes place in the deeper layers of the branch. The outer parts, though dead, still adhere to the stem for some considerable time, but ultimately fall away, leaving it brown and covered with loose, thin scales of cork.

The spines borne on the apices of spine-branches or at the extremities of accessory branches are generally roughly triangular in section, and are always green; but no phellogen formation takes place here, and the whole spine ultimately dies, but in most cases adheres to the stem in a dry state for a considerable period after all trace of life has disappeared.

The flowers are borne at the extremities of short peduncles, each of which is provided with a pair of very small lateral prophylls, and arises in the axil of a spine-

leaf. These spinescent bract-leaves are, in most cases, the spine-leaves borne on spine-branches near the apex of the shoot, but may be the higher spine-leaves of the shoot itself, in which case the flowers replace the spine-branches of the first generation on that branch, while in the former case they replace the secondary spine-branches.

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REPORT ON THE BOTANY OF THE MOFFAT DISTRICT FOR 1892. By J. THORBURN JOHNSTONE.

Owing to circumstances I was unable to devote much time to botanical pursuits last year, and in consequence I have not many plants to record for the year.

Subularia aquatica, L., Aug. 7. Loch Skene.

Melilotus arvensis, Willd., = *officinalis*, Desv., Aug. 27. Casual plant in own garden.

Trifolium arvense, L., Aug. 5. Barnhill sandpit, per J. M'Andrew.

Ornithopus perpusillus, L., June 19. Dumfries Road at Lochhouse Tower.

Æthusa Cynapium, L., July 27. Wamphray.

Meum Athamanticum, Jacq., June 25. Pastures on Whitecoomb, elevation 1750 feet.

Hieracium umbellatum, L., Sept. 4. Alton Mote.

In the "Journal of Botany" for July and September 1892, the following Hieracia are given by Messrs. E. F.

and W. Linton for Dumfriesshire, having stations at Spoon Burn, Correferron, Blacks Hope, etc.:—

Hieracium rubicundum, F. L. H. n. sp.
Hieracium murorum, var. *sarcophyllum*, Stenstr.
Hieracium duriceps, F. L. H.
Bromus commutatus, Schrad., Aug. 8. Holm fields.

I have also to note the following plants as occurring at Crawford and Abington, Lanarkshire:—

Draba muralis, L., May 14. Roadside at Abington.

Vicia sylvatica, July 19. Roadside bank between Camp Water and Medlock.

Hieracium gothicum, July 19. Roadside bank between Camp Water and Medlock.

Veronica hederæfolia, June 21. Waste ground at Abington.

ON TEMPERATURE AND VEGETATION IN THE ROYAL BOTANIC GARDEN, EDINBURGH, during the month of JANUARY 1893. By ROBERT LINDSAY, Curator of the Garden.

During the early part of January, severe frost prevailed. A change set in on the 15th of the month, after which the temperature rose gradually, with but slight interruption, till the close of the month, when fairly mild and genial weather prevailed. Falls of snow occurred frequently during the first half of the month. The thermometer was at or below freezing point on eighteen mornings, indicating collectively 100° of frost for the month, as against 136° for the corresponding month last year. The lowest reading was registered on the morning of the 6th, when the glass went down to 9°, or 23° of frost, the lowest point reached this winter, so far. No other very low readings were registered during the month, the lowest being on the 3rd, 24°; 5th, 22°; 7th, 22°; 12th, 23°. The lowest day temperature was 32° on the 2nd and 5th, and the highest 55° on the 31st of the month. Of the forty selected plants whose dates of flowering are annually recorded to the Society, the following came into flower, viz.:—*Dondia Epipactis* on January 16th; *Eranthis hyemalis*, January 25th; *Galanthus plicatus*,

January 28th; *G. nivalis*, January 30th. At the same date last year one only had flowered.

On the rock-garden 13 plants came into flower, as against 7 last January, viz:—*Andromeda floribunda, Colchicum crociflorum, Erica herbacea alba, Hepatica angulosa, H. triloba*, vars., *Helleborus purpurasceus*, var., *H. torquatus, Primula variabilis, Saxifraga Burseriana, Synthiris reniformis*, and three of the selected plants just mentioned.

Among hardy shrubs, the most conspicuous in blossom are *Jasminum nudiflorum, Garrya elliptica, Hamamelis japonica*, and the autumn-flowering variety of *Daphne Mezereum*. The russet-brown tints of *Biota orientalis*, which were so prominent a feature last month, have already undergone a change. The foliage is now almost green. The transitions are taking place much earlier than usual.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during January 1893.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	28°	32°	36°	17th	32°	35°	45°
2nd	25	28	32	18th	37	40	49
3rd	24	29	35	19th	37	41	46
4th	25	28	33	20th	33	44	52
5th	22	23	32	21st	31	37	43
6th	9	22	34	22nd	33	44	52
7th	22	32	37	23rd	37	46	51
8th	30	37	41	24th	42	44	52
9th	32	33	40	25th	35	37	47
10th	32	35	40	26th	31	43	45
11th	27	28	38	27th	34	38	46
12th	23	28	39	28th	33	36	45
13th	27	28	36	29th	37	39	55
14th	28	29	36	30th	34	40	54
15th	28	33	39	31st	40	42	55
16th	36	37	46				

[TABLE

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of January 1893.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	30·001	35·9	29·1	31·8	38·0	E.	Cum.	8	E.	0·010
2	30·062	32·5	28·0	30·0	25·9	N.E.	Cum.	10	N.E.	0·010
3	30·023	33·1	27·2	32·3	31·8	N.E.	Nim.	10	N.E.	0·020
4	30·297	33·6	28·0	30·8	30·8	S.E.	Nim.	10	S.E.	0·065
5	30 305	31·6	24·8	25·0	24·7	Calm.	Cum.	10	N.W.	0·020
6	30·130	25·7	9·9	24·8	24·2	Calm.	Nim.	10	...	0·010
7	29·991	33·2	23·8	33·7	32·0	E.S.E.	Cum.	10	E.S.E.	0·080
8	29·877	36·7	32·2	36·9	35·2	E.N.E.	Nim.	10	E.N.E.	0·005
9	29·841	38·1	35·9	36·1	35·0	E.	Cum.	6	E.	0·010
10	30·110	38·7	35·2	37·8	36·0	N.E.	Cum.	10	N.E.	0·000
11	30·383	38·9	31·0	31·2	30·4	W.	...	0	...	0·000
12	30·221	34·9	26·0	30·5	30·0	W.	...	0	...	0·000
13	29·942	37·1	29·9	37·4	36·1	N.W.	...	0	...	0·010
14	29·664	39·9	30·3	31·6	30·8	N.W.	Nim.	10	N.	0·010
15	30·168	35·1	29·0	33·0	31·2	N.W.	Cum.	8	N.W.	0·075
16	29·623	38·6	32·0	38·7	38·2	W.	Cir. St.	10	N.W.	0·120
17	29·723	44·1	34·0	37·0	36·7	N.W.	Cir. St.	10	N.	0·005
18	29·909	44·5	36·1	44·8	42·5	W.	Cir.	3	N.W.	0·000
19	30·079	48·6	41·2	43·8	42·4	S.W.	{ Cir. Cum.	6 2	W. S.W. }	0·030
20	30·024	47·8	36·1	37·1	35·6	W.	Cir.	3	N.W.	0·000
21	30·205	40·0	33·7	37·1	35·0	N.W.	Cum.	10	N.W.	0·000
22	30·102	43·9	33·6	44·1	43·1	W.	Cir. St.	10	N.W.	0·000
23	29·857	49·0	44·7	49·1	47·2	W.	Cir. St.	10	N.	0·000
24	29·681	50·0	45·0	45·2	43·0	W.	Cir. Cum.	2	W.	0·000
25	29·858	50·8	39·0	39·6	37·9	W.	...	0	...	0·025
26	29·225	46·0	34·9	45·4	43 0	S.W.	Cir.	4	S.W.	0·015
27	29·768	46·0	37·1	40·1	39·2	W.	Cum.	6	W.	0·000
28	29·496	44·1	35·0	38·5	35·0	S.	Cum.	10	S.	0·010
29	29·186	44·7	37·7	42·2	41·2	S.	Cum.	10	S.	0·035
30	29·623	49·9	39·0	46·4	44·6	S.W.	Cir. St.	6	S.W.	0·080
31	29·390	52·6	43·7	44·4	42·4	S.S.W.	Cum.	4	S.S.W.	0·075

Barometer.—Highest Observed, on the 11th, = 30·383 inches. Lowest Observed, on the 29th, = 29·186 inches. Difference, or Monthly Range, = 1·197 inch. Mean = 29·896 inches.

S. R. Thermometers.—Highest Observed, on the 31st, = 52°·6. Lowest Observed, on the 6th, = 9°·9. Difference, or Monthly Range, = 42°·7. Mean of all the Highest = 40°·8. Mean of all the Lowest = 33°·0. Difference, or Mean Daily Range, = 7°·8. Mean Temperature of Month = 36°·9.

Hygrometer.—Mean of Dry Bulb = 37°·3. Mean of Wet Bulb = 36°·1.

Rainfall.—Number of Days on which Rain fell = 21. Amount of Fall = 0·720 inch. Greatest Fall in 24 hours, on the 16th, = 0·120 inch.

A. D. RICHARDSON,
Observer.

MEETING OF THE SOCIETY.

Thursday, March 9, 1893.

Dr. DAVID CHRISTISON, President, in the Chair.

Lady CHRISTISON was elected Resident Fellow of the Society.

WILLIAM HENRY WILKINSON was elected Non-Resident Fellow of the Society.

Presents to the Library at the Royal Botanic Garden were announced; amongst them being a set of the "So Moku Zusetzu," a valuable illustrated work of the Botany of Japan, presented by A. Coxon, Esq., 8 William Street, London; and the "Yoduko So Yoku Dyusetzu" and the "So Moku Seifu," presented by the Director of Kew Gardens.

The CURATOR exhibited plants of *Rhododendron racemosum*, *Anigozanthus brevifolius*, and *Saxifraga Burserian Boydii* in flower, from the Royal Botanic Garden; also a branch in bloom of *Rhododendron dahuricum*, var. *atrovirens.*

The Rev. DAVID LANDSBOROUGH sent for exhibition cut specimens of species of *Eucalyptus* grown in the island of Arran, including *E. pauciflora* and *E. alpina*, both with ripe fruit; also a flowering branch of *Cordyline australis* from a plant grown in similar circumstances in Arran.

The following papers were read:—

OROBANCHE CRUENTA, BERTOLONI, IN SCOTLAND. By ARTHUR BENNETT.

Some years ago an old member of the London Botanical Society gave me a collection of plants that he had no use for; they were such as he had at various times received

Issued November 1893.

through the Society. Among them was an *Orobanche* named *O. elatior*, and labelled from the neighbourhood of Oban, Argyllshire. At the time I did not possess, nor had I gathered, *O. elatior*. When, some years after, I saw the plant growing plentifully in Surrey, and dried a good series in various stages, I saw the Oban plant was not *O. elatior*, and then contented myself with writing on the sheet, "Certainly not *O. elatior*."

A year or so after this, I gathered a good series of *O. caryopyllacea* in Kent, among them a very curious fern, which, unfortunately, I did not notice when fresh. However, last year, my friend, Mr. Miller, sent me from the Channel Isles a series of orobanches, which, unfortunately, were gathered too late to dissect with any satisfaction, though I saw there was one, at least, unrecorded from the Isles, viz., *O. rubra*, Sm., and another which is doubtless new to Britain. This caused me to dissect all my specimens, and on coming to the Oban one, I saw it could not be referred to any known British species. Comparison with descriptions in books, and the Kew and British Museum Herbaria, showed it to be *O. cruenta*, Bert. This plant, judging by the specimens seen, and its synonymy, is a very variable plant. Whether there are any more specimens extant in British herbaria I cannot say, but I could find none such in the British Herbarium at South Kensington, but I hope to look through Borrer's and Watson's collections this spring.

It will be very desirable that the species should be sought for in Argyllshire this summer, before one gives a description of the plant, etc. It will be well to say that it grows on *Genista tinctoria*, *Hippocrepis comosa*, *Lotus corniculatus*, *Lathyrus pratensis*, *Hedera helix*, *Anthyllis vulneraria*, *Ononis arvensis*, *Onobrychis sativa*, etc. The flowers are generally yellowish towards the base, then purple, and of a blood-red towards the throat.

I send this note in the hope that some will search for it, as I have already asked the local botanists to do.

A NOTICE OF MR. R. MARSHAM, OF STRATTON, NORFOLKSHIRE, A SCIENTIFIC INVESTIGATOR OF FORESTRY OF LAST CENTURY. By Dr. DAVID CHRISTISON, President.

In all ages, and probably in every science, there have been investigators who were in advance of their time. Many such are well-known to fame, but there are others who, either from an excess of modesty, or from a want of appreciation of the value of their work, or for some other reason, have taken no efficient steps to make known their observations, which, consequently, either have been imperfectly preserved or have been altogether lost to science. Such seems to have been the case with the subject of this brief notice, to whom my attention was drawn by the following accident.

In the posthumous volume of Essays by Dr. John Walker, Professor of Natural History in Edinburgh University during the latter part of last century, reference is made to the dimensions of the great oak at Cowethorp given by Mr. Beevor in "Bath Memoirs, 1780." In the hope of finding measurements of other trees, at this early period, by Mr. Beevor, I looked up the reference, but with much difficulty, as Professor Walker, alarmed apparently by the formidable length of the title, "Letters and Papers on Agriculture, Planting, etc. Selected from the Correspondence Books of the Bath Society for the encouragement of Agriculture, Arts, Manufactures, and Commerce. Bath, 1780," had contracted it in his reference so as to make it almost unrecognisable. Having searched the catalogues of the Edinburgh libraries in vain, it occurred to me that the proper place to hunt for "Bath Memoirs" was in Bath, and by the kindness of Mr. Dymond, the distinguished archæologist, Curator of the Bath Library, the hunt was at last successful. On turning up the passage the necessity for verifying quotations was exemplified, as it turned out that Mr. Beevor was not the measurer of the Cowethrop Oak at all, nor apparently of any other tree, but had merely forwarded to the Editor the measurements of Mr. Marsham. Thus I lost Mr. Beevor but found Mr. Marsham, a Norfolk squire, who, in the middle of last century, a period when the manners of his class are depicted to us as

generally so rude and rough, had apparently been engaged in the study of forestry for forty or fifty years. Most unfortunately, however, the records, which we cannot doubt that he must have kept, were never published, and all that we know of his work is contained in the letter already mentioned, and in another to the Bishop of Bath and Wells, in the Philosophical Transactions for 1777, Vol. 67, p. 12.

In the former letter, besides the measurements of the Cowethorp tree, Mr. Marsham gives the results of experiments upon an oak planted by himself in 1720. The size at that time he did not remember, but in the autumn of 1742 it was 2 feet 11¾ inches in girth at about breast-height, and in 1778 it had increased to 7 feet 9 inches. The annual rate, therefore, for the whole period was 1·60 inch, and for the last thirty-six years 1·58 inch. This is a very high rate for an oak, but he explains that it may have been due to special causes:—"It was taken from very poor land to a tolerable light soil, and stands single; and perhaps the growth was helped by digging a large circle round it in several winters, and in other years having that circle covered with greasy pond-mud. In some seasons I washed the stem; and the advantage of washing I experienced in 1775, greatly to my satisfaction."

He then refers for a full account of his washing experiments to his letter to the Bishop of Bath and Wells. In this letter, however, there is nothing about the oak, but he gives the following account, which I have abridged, of experiments on a beech:—"Putting in practice Dr. Hale's advice (as to washing) and Evelyn's (as to rubbing), in spring 1776, as soon as the buds began to swell, I washed my tree from the ground to the beginning of the head, viz., 13 to 14 feet in height; first with water and a stiff shoe-brush, till the tree was quite clean, then with coarse flannel, three, four, or five times a week, during the dry time of spring and the fore part of summer, but after the rains I seldom washed." He then gives the comparative girth-increase of the washed and of an unwashed beech for the season. Both trees were sown in 1741, and transplanted to a grove in 1749. The washed tree was the largest till 1767, after which its rival gained upon it, so

that in 1776, when the experiment was made, the two were almost identical in size, but, to make the result quite reliable, he chose as the tree to be washed the one which was the least thriving of the two at the time. He also took the increase of five other beeches of the same age for further comparison, and here follow the results:—

TREE.	Girth, 1776.	Increase, 1776.
	Ft. In.	Inches.
Unwashed Beech, . . .	3 $7\frac{9}{10}$	1·20
Washed Beech, . . .	3 $7\frac{2}{10}$	2·50
Average of five, unwashed, . .	...	1·50

The increase in the washed tree is so remarkable as to cast some doubt on the accuracy of the observation, particularly as the actual increase must have exceeded $2\frac{1}{2}$ inches, because there must have been a certain diminution in the girth from the scrubbing. Yet it is hardly possible to doubt the accuracy of an investigator who was evidently so careful in his methods.

From the few hints furnished by his two letters we can see that the Norfolk squire anticipated modern methods by more than a century, in advocating 5 feet as the proper height for taking the girth of a tree, in taking girth-measurements to the fineness of a tenth of an inch, and in making experiments on manuring the soil and washing the stems in stimulating the growth of trees.

Experiments on the effects of manuring upon tree growth, although advocated fifteen years ago by Sir Robert Christison, so far as I am aware, have not yet been carried out in a scientific way, by comparing the girth-increase of manured and unmanured trees, and by trying different manures. A great field for experiment here lies open, requiring no higher qualifications than patience and accuracy, which might afford an agreeable change to the shooting, fishing, and hunting which are still, as in the time of our Norfolk squire, the too exclusive occupations of our country gentry. As to the scrubbing and washing of the stems of trees I do not know that any experiments have been made since those of Mr. Marsham, but the very remarkable results which he appears to have got certainly

encourage further trial in our own day. It does not quite appear whether he attributed any virtue to the moistening of the bark as well as to the cleansing of it, but when we consider the long exposure of our trees with their tender young buds to the parching east winds of spring, it is reasonable to conclude that frequent drenching of the bark at that season might be very beneficial, not only to the functions of the bark, but by the general supply of moisture to the tree. In his trees obstruction to the functions of the bark could only arise from lichen or other vegetable growths; but in our town trees the deposit from smoke is perhaps more prejudicial to health, and is certainly more unsightly, and although it would be impracticable to scrub the whole bark-surface of large trees, it might be found beneficial, and it certainly would be an improvement to appearance, if the stems at least could be cleaned from the incrustation of soot which now disfigures them. Should such experiments be made, and prove of utility, it ought not to be forgotten that the credit of being among the first to initiate them was due to Mr. R. Marsham, of Stratton, more than a century ago.

ON TEMPERATURE AND VEGETATION IN THE ROYAL BOTANIC GARDEN, EDINBURGH, during the month of FEBRUARY 1893. By ROBERT LINDSAY, Curator of the Garden.

During February the thermometer was at or below the freezing point on eleven occasions, indicating collectively 64° of frost for the month, as against 114° for the corresponding month last year. The lowest readings occurred on the 13th, 23°; 24th, 22°; 25th, 20°; 26th, 26°; 28th, 21°. The lowest day temperature was 39°, on the 24th, and the highest 58°, on the 19th. A good deal of snow fell during the last week of the month. Up till the 23rd, fine mild weather prevailed, and spring-flowering plants came rapidly into blossom. The hybrid *Rhododendron præcox* had all its flowers destroyed by frost on the 25th, while one of its parents, *R. dahuricum*, is quite uninjured, and is flowering more profusely this season than has been observed for some years.

Of the forty spring-flowering plants whose dates of

flowering are annually recorded, the following 15 came into flower:—*Rhododendron atrovirens*, on February 4th; *Tussilago fragrans*, 6th; *Leucojum vernum*, 6th; *Corylus Avellana*, 8th; *Crocus susianus*, 8th; *Bulbocodium vernum*, 10th; *Scilla præcox*, 10th; *Crocus vernus*, 14th; *Scilla siberica*, 14th; *Rhododendron Nobleanum*, 14th; *Symplocarpus fœtidus*, 14th; *Tussilago alba*, 18th; *T. nivea*, 18th; *Daphne Mezereum*, 19th; *Nordmannia cordifolia*, 20th.

On the rock-garden 40 species and varieties came into flower during the month, as against 31 during February 1892, the most interesting being *Chionodoxa sardensis*, *Daphne Blagayana*, *Galanthus Imperati*, *Hyacinthus azureus*, *Leucojum carpaticum*, *Narcissus minimus*, *Polygala chamæbuxus*, *Primula denticulata*, *Ranunculus anemonoides*, *Rhododendron præcox*, *Saxifraga imbricata*, *S. oppositifolia*, *S. pyrenaica superba*, etc. Several half-hardy plants have sustained severe injury by frost, chiefly during the previous month. The worst affected are *Eucalyptus coccifera*, *Edwardsia microphylla*, *Cordyline australis*, *Genista aspalathoides*, *Polygonum vaccinifolium*, *Veronica Andersonii*, *V. angustifolia*, *V. parviflora*, *V. chathamica*, and *Erica australis*.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during February 1893.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	34°	37°	45°	15th	37	39	48
2nd	34	37	51	16th	39	41	49
3rd	35	40	52	17th	32	40	52
4th	39	45	50	18th	37	51	54
5th	36	42	46	19th	40	44	58
6th	30	41	43	20th	42	43	48
7th	37	41	52	21st	33	36	41
8th	37	45	48	22nd	35	36	39
9th	35	43	51	23rd	30	32	41
10th	33	40	49	24th	22	25	39
11th	36	40	41	25th	20	30	40
12th	31	36	49	26th	26	33	41
13th	23	25	41	27th	29	36	42
14th	24	38	51	28th	21	36	42

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of February 1893.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·618	46·8	36·2	37·8	37·0	W.	Cir. St.	10	W.	0·035
2	29·577	43·6	36·1	38·6	37·7	W.	...	0	...	0·030
3	29·980	44·1	37·2	42·2	42·0	W.	Cum.	8	W.	0·000
4	30·102	49·8	41·9	45·9	43·0	S.W.	Cum.	8	S.	0·000
5	30·168	48·1	38·3	42·2	39·8	S.W.	Cir.	2	S.W.	0·000
6	30·080	45·9	33 0	42·5	40·4	S.W.	Cum.	10	S.W.	0·025
7	29·709	48·9	42·1	43·9	41·9	W.	...	0	...	0·070
8	29·418	48·3	38·5	40·0	37·8	N.W.	Cum.	10	N.W.	0·000
9	29·424	44·8	36·8	44·8	43·1	S.W.	Cum.	10	S.W.	0·440
10	28·821	47·8	36·5	39·2	38 5	W.	Cir.	1	W.	0·060
11	29·099	49 0	38·6	40·9	38·1	W.	Cir.	1	W.	0·040
12	29·499	44·3	33·3	33·9	31·6	N.W.	Cir.	3	N.W.	0·005
13	29·486	39·7	27·0	28·2	28·2	N.	Cir.	2	N.	0·380
14	28·839	40·1	27·9	40·6	40·1	E.	Nim.	10	S.	0·165
15	29·419	49·8	35·7	38·0	35·2	S.W.	...	0	...	0·015
16	29 222	46·8	37·3	41·6	40·9	S.S.E.	Cum.	10	S.S.E.	0·075
17	29·610	46·8	33·9	37·5	36·0	S.W.	...	0	...	0·080
18	29·524	51·0	36·8	51·2	49·5	W.S.W.	Cum.	10	W.S.W.	0·005
19	29·569	53·8	43 2	44·0	43·8	Calm.	Cum.	10	S.W.	0·010
20	29·228	53·9	42·5	43·1	41·8	S.	Cir. St.	10	S	0·000
21	28·842	51·0	37·0	33·6	32·6	E.	Cum.	10	N.E.	0·190
22	29·273	41 0	37·6	37·9	35·6	N.E.	Cum.	10	N.E.	0·020
23	29·416	37·9	32·1	33·8	32·0	E.	Cum.	10	E.	0·000
24	29·300	38·4	26·8	29·2	27·9	W.	Cum.	6	N.E.	0·000
25	29·192	38·5	25 0	28·3	28·0	S.W.	...	0	...	0·005
26	29·084	37·9	27·6	35·1	32·8	E.	Cir. St.	10	E.	0·730
27	28·826	35 0	31 8	34·7	32·0	W.	Cir.	4	W.	0·000
28	29·442	39·9	25·5	35·3	32·1	S.W.	Cir.	8	W.	0·045

Barometer.—Highest Observed, on the 5th, = 30·168 inches. Lowest Observed, on the 27th, = 28·826 inches. Difference, or Monthly Range, = 1·342 inch. Mean = 29·420 inches.

S. R. Thermometers.—Highest Observed, on the 20th, = 53°·9. Lowest Observed, on the 25th, = 25°·0. Difference, or Monthly Range, = 28°·9. Mean of all the Highest = 45° 1. Mean of all the Lowest = 34°·9. Difference, or Mean Daily Range, = 10°·2. Mean Temperature of Month = 40°·0.

Hygrometer.—Mean of Dry Bulb = 38°·7. Mean of Wet Bulb = 37°·1.

Rainfall.—Number of Days on which Rain fell = 20. Amount of Fall = 2·425 inches. Greatest Fall in 24 hours, on the 26th, = 0·730 inch.

A. D. RICHARDSON,
Observer.

MEETING OF THE SOCIETY,

Thursday, April 13, 1893.

Dr. David Christison, President, in the Chair.

Mrs. Bayley Balfour was elected Resident Fellow of the Society.

Presents to the Library at the Royal Botanic Garden were announced. These included a folio volume of original drawings of the famous traveller Mungo Park, which had been received from Miss Brown, of Langfin.

The Curator exhibited plants of *Cassiope fastigiata* and *Xerophyllum asphodeloides* from the Royal Botanic Garden.

Mr. Campbell sent for exhibition cut blooms of *Escallonia macrantha, Erica carnea*, and species of *Acacia* from plants grown in open air in his garden at Ledaig, Argyllshire.

Professor Bayley Balfour exhibited the *Sclerotium Tulasnii* on tulip bulbs.

Professor Somerville sent for exhibition *Cordyceps militaris* from Northumberland.

The President exhibited drawings of the Ash tree of Logierait, Ross-shire.

Mr. Forgan exhibited a root of *Cupressus Lawsoniana* with a large tuber formed on a plant grown in a small pot.

The following Papers were read :—

The Genus Latania, and notes on Mascarene Palms By Professor Bayley Balfour.

Issued November 1893.

THE ORIGIN OF THE POMEGRANATE. By Professor BAYLEY BALFOUR.

LIFE-HISTORY OF PINGUICULA VULGARIS. By T. D. SADLER.

The author gave an interesting and critical summary of what is known of the morphology and physiology of this plant. The following list includes the chief literature of the subject:—

ALLMAN, PROFESSOR.—Note on the Probable Migration of *Pinguicula grandiflora* through the Agency of Birds.—Jour. Linn. Soc. London, XVII., 1878, pp. 157–58.

BOUCHE, C. D.—On the cultivation of *Pinguicula orchidioides*.—Gard. Chron., 1850, pp. 756–57.

BUCHENAU, FRANZ.—Morphologische Studien an Deutschen Lentibularieen.—Bot. Zeitung, XXIII., 1865, pp. 61–66, 69–71, 77–80, 85–91, 93–99.

CANDOLLE, A. DE.—Pinguicula (monograph).—Prodromus, VIII., 1843, pp. 8–27.

CASPARY, R.—Ueber Samen u. Keimung von *Pinguicula vulgaris*.—Schrift. Phys. ök. Ges. Königsberg, VIII., 1867, p. 16.

DANGEARD, P. A.—Nouvelles observations sur les Pinguicula.—Bull. Soc. Bot. de France, XXXV., 1888, pp. 260–62.

DANGEARD, P. A., ET BARBE.—La Polystélie dans le genre *Pinguicula* —Bull. Soc. Bot. de France, XXXIV., 1887, pp. 307–9.

DARWIN, C.—Insectivorous Plants.—1st ed. 1875; 2nd ed. 1888, pp. 297–318.

DICKSON, PROFESSOR A.—On the Development of the Flower of *Pinguicula vulgaris*, L.; with Remarks on the Embryos of *P. vulgaris*, *P. grandiflora*, *P. caudata*, and *Utricularia minor*.—Trans. Roy. Soc. Edin., XXV., 1869, pp. 639–54; and Proc., VI., pp. 531–34.

A short note on the Embryos of *P. vulgaris* and *P. grandiflora*, by the same author, is to be found in the Quart. Jour. Micros. Sc., VIII., pp. 121–22.

DUCHARTRE, P.—Observations sur la *Pinguicula caudata*, Schlecht.—Bull. Soc. Bot. de France, XXXIV., 1887, pp. 207–216; and in Jour. Soc. Nat. d'Hortic. de France, 1887.

FOURNIER, E.—*Pinguicula soladium*.—Bull. Soc. Bot. de France, XX., 1874, LXVII.

GENTY, A.—Contributions à la monographie des Pinguiculacees européennes, I., sur un nouveau Pinguicula du Jura français, *P. Reuteri*, Genty, et sur quelques espèces critiques du même genre. —Jour. de Bot., 1891.

HECKEL, ED.—Du movement dans les poils et les laciniations foliares du *Drosera rotundifolia* et dans les feuilles du *Pinguicula vulgaris*.—Comptes rendus, 1876, pp. 525–26.

HELMSLEY, W. B.—Butterworts.—Garden, 1881, pp. 212–13.

HOOKER, J. D.—*Pinguicula candata*.—Bot. Mag., 1882, tab. 6624.

HOOKER, W. J.—*Pinguicula orchidioides*.—Bot. Mag., 1846, tab. 4231.

HOVELACQUE, M.—Sur les propagules de *Pinguicula vulgaris*.—Comptes rendus, etc., 1888.

KLEIN, J,—*Pinguicula alpina* als insectenfressende Pfanze und in anatomischer Beziehung.—Cohn's Beitr. sur Biol. Pfl., III., 1880, pp. 163–84.

KLEIN, J.—Epidermis der Blätter von *Pinguicula alpina*, Spaltöffnungen der Blätter von *P. alpina*, Bau des unterirdischen Stammchens von *P. alpina*, Bau der Wurzeln von *P. alpina*, Bau des Blattes von *P. alpina*.—In K. Goebel's "Zur Embryologie der Archegoniaten" in Arbeit. de Botan. Inst. in Würzburg, II., S. 437, 1880.

KLEIN, J.—Die Zellkern-Krystalloide von *Pinguicula* und *Utricularia*. —Pringsheim's Jahrbücher, XIII., 1882, pp. 60–73.

LAMARCK, J. B.—Sur une nouvelle espèce de Grassette.—Jour. d'Hist. Nat., I., 1792, pp. 334–38.

LANKESTER, E.—On the Epidermal Appendages of the Genera *Callitriche*, *Hippuris*, *Pinguicula*, and *Drosera*.—Brit. Assoc. Report, 1850.

MORREN, E.—Observations sur les procédès insecticides des Pinguicula. —Bull. Acad. Roy. d. Belgique, XXXIX., 1875; and La Belgique Horticole, 1875, p. 290.

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RUSSOW, E.—Ueber das Vorkommen von Krystalloiden bei *Pinguicula vulgaris*.—Ebenda, Oct. 1880.

TISCHUTKIN, N.—Die Rolle der Bacterien bei der Veränderung der Eiweisstoffe auf den Blattern von *Pinguicula*.—Bericht. Deut. Botan. Gesell., VII., 1889, pp. 346–55; Arb. St. Petersburg Naturf. Gesell. (Bot.), 1891, pp. 33–37.

TREVIRANUS, L. C.—Hat *Pinguicula vulgaris*, Linn., zwei Cotyledonen? —Bot. Zeitung, VI., 1848, pp. 441–44.

WARMING, E.—Bidrag til Kundskaben om Lentibulariaceen.—Vidensk. Meddel. Nat. For., Copenhagen, 1874.

WEISS, Ad.—Entwickelungsgeschichte des Trichome im Corollenschlunde von *Pinguicula vulgaris*, L.—Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Wien, 1891.

ON TEMPERATURE AND VEGETATION IN THE ROYAL BOTANIC GARDEN, EDINBURGH, during the month of MARCH 1893. By ROBERT LINDSAY, Curator of the Garden.

During the month of March the thermometer was at or below the freezing point on fifteen mornings. The total amount of frost registered for the month was 64°, as against 156° for the corresponding month last year. The lowest temperatures were indicated on the mornings of the 17th, 27°; 18th, 23°; 19th, 21°; 21st, 26°; 22nd, 26°. The day temperatures were high, the lowest being 40°, on the 1st, and the highest 69°, on the 25th. There was a large amount of bright sunshine, and on the whole the month was a most favourable one.

Vegetation generally has made good progress. The leaf-buds of deciduous trees and shrubs are well forward, and only require some genial showers of rain to enable them to expand. The different varieties of flowering currant are in full blossom; *Rhododendron Nobleanum* was flowering most profusely till injured by frost on the 19th. Of the

forty spring-flowering plants whose dates of flowering are annually recorded, the following twenty came into flower during March, viz.:—*Orobus vernus*, on March 2nd; *Sisyrinchium grandiflorum*, 2nd; *Arabis albida*, 3rd; *Iris reticulata*, 3rd; *Sisyrinchium grandiflorum album*, 5th; *Scilla bifolia*, 6th; *S. bifolia alba*, 7th; *S. taurica*, 7th; *Narcissus pumilus*, 10th; *Erythronium Dens-canis*, 13th; *Adonis vernalis*, 13th; *Draba aizoides*, 13th; *Omphalodes verna*, 15th; *Ribes sanguineum*, 17th; *Hyoscyamus Scopolia*, 18th; *Aubrietia grandiflora*, 20th; *Narcissus Pseudo-Narcissus*, 23rd; *Corydalis solida*, 24th; *Symphytum caucasicum*, 24th; *Mandragora officinalis*, 26th. *Fritillaria imperialis* came into flower on April 3rd, which completes the list much earlier than usual.

On the rock-garden 81 species and varieties came into flower, the largest number that we have had to record for March. Last year 39 came into flower during March. Amongst the most interesting were—*Anemone bracteata*, *Draba aizoides*, *D. Maweana*, *Dentaria pentaphylla*, *Corydalis angustifolia*, *Epigæa repens*, *Hyoscyamus orientalis*, *Iberis saxatilis*, *Menziesia empetriformis*, *Orobus cyaneus*, *Primula cashmiriana*, *P. marginata*, *P. integrifolia*, *Podophyllum Emodi*, *Rhodothamnus Chamæcistus*, *Rhododendron ciliatum*, *Saxifraga juniperina*, *S. sancta*, *S. retusa*, *S. Milesii*, *S. Rocheliana*, *Scopolia Hladnikiana*, *Soldanella montana*, *Xanthorrhiza apiifolia*, *etc.*

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during March 1893.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	28°	30°	40°	17th	27°	36°	43°
2nd	30	38	45	18th	23	37	44
3rd	29	37	49	19th	21	35	54
4th	35	44	51	20th	40	49	54
5th	36	46	60	21st	26	35	60
6th	42	45	60	22nd	26	44	66
7th	38	49	59	23rd	27	42	68
8th	38	43	55	24th	28	47	68
9th	42	45	57	25th	31	42	69
10th	32	40	53	26th	35	47	65
11th	35	42	47	27th	35	41	47
12th	37	46	53	28th	28	40	48
13th	34	45	53	29th	32	40	51
14th	34	44	50	30th	33	52	61
15th	35	43	51	31st	34	48	63
16th	28	35	42				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of March 1893.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches)
		°	°	°	°					
1	29·335	40·0	32·4	32·8	32·1	E.	Nim.	10	E.	0·275
2	29·634	38·5	32·1	38·8	38·6	W.	Cir. St.	10	N.W.	0·001
3	30·097	41·9	31·4	38·5	36·2	Var.	Cir. St.	10	S.W.	0·045
4	29·762	48·8	37·9	46·2	44·0	W.	Cum.	10	W.	0·020
5	29·931	50·5	43·8	49·3	47·2	S.W.	Cir.	6	N.W.	0·000
6	30·049	56·0	44·8	46·0	44·8	S.W.	Cum.	10	S.W.	0·100
7	30·000	52·5	41·6	50·0	48·5	S.W.	Cum.	10	S.W.	0·000
8	30·162	56·8	41·0	44·8	42·6	W.	Cir. Cum.	6	N.W.	0·000
9	29·845	52·0	44·0	47·3	45·0	W.	Cum.	8	W.	0·000
10	29·970	54·8	37·8	43·7	39·1	W.	...	0	...	0·000
11	29·897	49·8	38·6	42·9	40·0	W.S.W.	Cum.	10	W.S.W.	0·000
12	29·578	48·0	42·6	47·8	43·2	S.W.	...	0	...	0·000
13	29·528	52·7	36·0	43·7	40·1	S.W.	...	0	...	0·000
14	29·620	50·5	36·1	43·1	40·0	S.W.	Cum.	10	S.W.	0·010
15	29·262	48·2	43·0	45·0	41·5	W.S.W.	Nim.	10	W.S.W.	0·135
16	29·279	50·8	31·6	35·1	32·6	S.W.	Cum.	3	W.	0·010
17	29·598	39·8	29·8	35·8	32·0	W.	Cir.	5	W.	0·000
18	30·114	39·9	27·0	35·2	31·8	N.N.W.	Cum.	1	N.N.W.	0·000
19	30·289	39·7	24·0	36·2	35·0	W.	Cum.	2	W.	0·000
20	30·244	49·2	36·0	49·1	45·8	W.	Cir.	1	W.	0·000
21	30·227	52·6	28·8	38·4	37·0	Calm.	...	0	...	0·000
22	30·174	58·7	29·4	45·9	41·4	W.	...	0	...	0·000
23	30·122	63·1	31·0	44·0	40·6	W.	...	0	...	0·000
24	30·233	63·8	31·1	47·9	43·4	W.	...	0	...	0·000
25	30·333	61·1	33·4	46·1	43·1	W.	...	0	...	0·000
26	30·245	66·2	33·0	44·1	41·9	N.E.	...	0	...	0·020
27	30·166	53·8	39·2	41·3	41·0	E.	Nim.	10	E.	0·000
28	30·199	47·0	31·1	38·6	36·8	E.	Cum.	10	E.	0·000
29	30·031	45·8	35·5	36·1	35·6	E.	St.	10	E.	0·000
30	29·790	49·4	35·5	49·7	46·7	W.	Cir.	3	N.W.	0·000
31	29·551	57·8	38·8	51·3	49·1	S.W.	Cir. / Cum.	2 / 2	W.	0·050

Barometer.—Highest Observed, on the 25th, = 30·333 inches. Lowest Observed, on the 15th, = 29·262 inches. Difference, or Monthly Range, = 1·071 inch. Mean = 29·912 inches.

S. R. Thermometers.—Highest Observed, on the 26th, = 66°·2. Lowest Observed, on the 19th, = 24°·0. Difference, or Monthly Range, = 42°·2. Mean of all the Highest = 47°·4. Mean of all the lowest = 36°·3. Difference, or Mean Daily Range, = 11°·1. Mean Temperature of Month = 41°·8.

Hygrometer.—Mean of Dry Bulb = 41°·3. Mean of Wet Bulb = 40°·2.

Rainfall.—Number of Days on which Rain fell = 10. Amount of Fall = 0·666 inch. Greatest Fall in 24 hours, on the 1st, = 0·275 inch.

A. D. RICHARDSON,
Observer.

MEETING OF THE SOCIETY,

Thursday, May 11, 1893.

Dr William Craig, Vice-President, in the Chair.

The Curator exhibited the following plants in flower in pots from the Royal Botanic Garden:—*Androsace arachnoidea*, *A. lactea*, *A. sarmentosa*, *Alyssum arachnoidea*, *Bellis perennis* (two monstrous vars. and crimson var.), *Dianthus alpinus* hybrid, *D. microlepis*, *Daphne rupestris*, *D. striata*, *Hellonias bullata*, *Houstonia cœrulea*, *Gentiana verna*, *Kernera saxatilis*, *Myosotis alpestris*, *Pinguicula vulgaris*, *Pentstemon Menziesii*, *Ranunculus auricomus* (abnormal variety), *Romanzoffia sitchensis*, *Saxifraga anceps*, *S. calyciflora*, *S. Launcestoni*, *S. MacNabiana*, *S. mixta*, *S. odontophylla*, *S. virginiensis*, *S. Seguierii*, *Trifolium uniflorum*, *Erica Chamissonis*, *Scilla Krauseii*.

Dr. Stuart, Chirnside, Berwickshire, sent cut flowers of hybrid *Trollius*, *T. europæus*, and *T. americanus*.

Mr. John Campbell sent cut flowers of *Wistaria sinensis*, *Deutzia gracilis*, *Cytisus fragrans*, *Spiræa hypericifolia*, etc., from plants in open air in his garden at Ledaig, Argyllshire.

Dr. J. H. Wilson exhibited a hybrid between *Passiflora cœrulea* and *P. Bonaparte*.

Mr. Malcolm Dunn exhibited branches, well set with fruit, showing the earliness of the season, of the following:—

Peach—Hale's Early, and Alexander, half-grown. Apricots—New Large Early, Moorpark, Hemskirke, etc., also fully half-grown. Apples—Ecklinville, The Queen, Loddington, Stirling Castle, etc. Pears—Beurre d'Amanlis,

Beurre Diel, Hessle, Louise Bonne of Jersey, etc. Plums —Kirke's, Early Transparent, and Jefferson, from walls; and Victoria, Pond's Seedling, and Early Prolific, from standards. Cherries—Frogmore Early Bigarreau, Early Orleans, and Early Lyons, from open wall. Gooseberries—Whitesmith, Early Kent, Industry, etc. Currants—Red Dutch, White Dutch, Cutleaved White, etc. Strawberries —John Ruskin, Noble, etc.

Professor Bayley Balfour exhibited the most recent addition to the Museum of the Royal Botanic Garden, of models for teaching purposes.

The following letter from the President at Stratford-on-Avon was read:—

I regret I shall not be able to attend the May meeting of the Society. Perhaps, if the Billet is not very full, a few notes on this extraordinary season, from the South, may be of interest to the members for comparison with your neighbourhood.

At Newland, Forest of Dean, Gloucestershire, I noticed the hawthorn in flower pretty generally on the 24th April, and I was informed that it began to flower fully a week earlier.

In the Public Garden at Bath on the 28th April, hawthorn, white and red, lilac, laburnum, and horse-chestnut were all in full bloom, and in such splendid condition as in some cases to conceal the leaves. I never saw a more splendid display, and as the other trees were in the fresh beauty of spring foliage, fully out, the scene was perfect of its kind.

On the 6th May, when I passed through Bath again, however, the beauty of the scene was over. In most of the trees the flowers had faded, and in many they were fast dropping to the ground. Thus the season has been both remarkably early and lamentably short.

At Bradford-on-Avon in the last week of April things were much in the same stage of advancement as in Bath. Half-a-dozen species of roses, wistaria, and clematis were in full bloom on the wall of Dr. Beddoe's garden and house,

and so was a standard pæony, two months before its time. Many other species were in flower, including the strawberry, and the general remark was that nothing was left for June. The foliage of all the forest trees, except the ash, was fully out, or nearly so, by the end of April; old walnuts well advanced on the 6th May, and mulberry trees expanding their leaves. The foliage everywhere fine, and no great parching of the grass or young crops, although, of course, everything was short. The total rainfall in sixty-seven days was under half-an-inch, falling on five days in March, one in April, and one in May. Latterly, at least, the air must have been very dry, as, in spite of clear nights, there was no dew. Fortunately there had been a heavy rainfall all through February.

Here, in the centre of England, the ground has a more parched aspect, and flowering seems to have been checked by the excessive drought. That is to say that flowering, though very early, is imperfect. Fruit, however, promises very well, pears are well formed, and gooseberries fit for cooking since the end of April.

My host, Dr. Carter, lately of Leamington, takes great interest in his trees, and treats them with the combined skill of a practical gardener, a man of science, and a man of medicine. He showed me several fruit trees, which were languishing, and apparently dying, from fungoid growths. He cut out the growths as if they had been cancers, and applied paraffin oil to the surfaces, and the trees are now flourishing.

Other fruit trees, suffering from insects harbouring in fissures and axils, were completely restored to health by eradication of the evil. From what he sees in other orchards, he is convinced much more attention should be paid to the fruit trees than they generally get.

He showed me the results of an interesting experiment. A few years ago he put in a number of young pear trees on the same piece of ground, which was all under grass. A part of the ground he dug up, as it was slightly ridged from old cultivation, and he wished to level it. This part has been left since free from grass. The trees planted there are now twice the size, and have twice as good heads as those planted in the undisturbed grass. The

effect he is inclined to ascribe to the grass intercepting the moisture and nourishment which would otherwise go to the roots of the pear trees; but the effect of turning up the soil has also to be considered.

The following paper was read:—

ON TEMPERATURE AND VEGETATION IN THE ROYAL BOTANIC GARDEN, EDINBURGH, during the month of APRIL 1893. By ROBERT LINDSAY, Curator of the Garden.

The past month of April has been one of the most favourable on record. Seldom has there been so little frost and so much sunshine during April, the only drawback has been the want of rain. Vegetation generally has made very rapid progress. The foliage of deciduous trees and shrubs is remarkably luxuriant, notwithstanding the lack of moisture: fortunately, drying winds have been less frequent than usual. The flowering of ornamental trees and shrubs is considerably above the average. Apple, pear, single and double cherry, currants and barberries being quite smothered with blossom. The thermometer was below the freezing point on four occasions, registering in all 12° of frost for the month, as against 72° for the corresponding month of last year. The lowest readings occurred on the 4th, 31°; 10th, 27°; 12th, 27°; 14th, 31°. The lowest day temperature was 44° on the 16th, and the highest 68° on the 20th.

The collective amount of frost registered this season up to the end of April is 517°, as against 620° for the same period last year. The following is the distribution for each month:—October, 44° of frost; November, 41°; December, 192°; January, 100°; February, 64°; March, 64°; April, 12°. The lowest point reached this season was 9° Fahr., or 23° of frost, which occurred on the 6th of January.

On the rock-garden 166 species and varieties came into flower during the month, as against 119 for April of last year. Among the more interesting were:—*Anemone Robinsoniana*, *Arnebia echioides*, *Asarum caudatum*, *Androsace coronopifolium*, *Aubrietia Hendersoni*, *A. Leichtlini*, *Bryan-*

thus erectus, *Cassiope fastigiata*, *Erythronium giganteum*, *Lamium Orvala*, *Muscari armeniacum*, *Phlox setacea* and varieties, *Polemonium humile*, *Primula integrifolia*, *P. Murettiana*, *P. magellanica*, *P. Sieboldii*, *P. viscosa*, *Rhododendron glaucum*, *Ranunculus uniflorus*, *R. speciosus*, *R. Traunfelneri*, *Saxifraga purpurascens*, *Trillium erectum*, *T. grandiflorum*, etc.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during April 1893.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	40°	42°	57°	16th	33°	35°	44°
2nd	35	50	60	17th	32	40	45
3rd	40	49	62	18th	46	48	58
4th	31	46	58	19th	44	54	66
5th	34	44	58	20th	42	54	68
6th	34	44	56	21st	39	48	52
7th	36	46	49	22nd	37	50	60
8th	40	42	57	23rd	41	44	56
9th	36	43	52	24th	32	47	66
10th	27	34	53	25th	35	50	62
11th	38	44	54	26th	40	45	61
12th	27	46	62	27th	35	52	65
13th	39	45	56	28th	40	54	62
14th	31	45	53	29th	39	43	53
15th	39	44	59	30th	35	51	59

[Table

REGISTER OF SPRING-FLOWERING PLANTS, SHOWING DATES OF FLOWERING, AT THE ROYAL BOTANIC GARDEN, EDINBURGH, DURING THE YEARS 1892 AND 1893.

No.	Names of Plants.	First Flowers opened.	
		1892.	1893.
1	Adonis vernalis.	April 9	March 13
2	Arabis albida,	March 22	,, 3
3	Aubrietia grandiflora,	April 9	,, 20
4	Bulbocodium vernum,	February 12	February 10
5	Corydalis solida,	April 10	March 24
6	Coryllus Avellana,	February 12	February 8
7	Crocus Susianus,	,, 12	,, 8
8	,, vernus,	,, 24	,, 14
9	Daphne Mezereum,	,, 24	,, 19
10	Dondia Epipactis,	,, 10	January 16
11	Draba aizoides,	April 3	March 13
12	Eranthis hyemalis,	February 6	January 25
13	Erythronium Dens-canis,	March 23	March 13
14	Fritillaria imperialis,	...	April 3
15	Galanthus nivalis,	February 2	January 30
16	,, plicatus,	January 26	,, 28
17	Hyoscyamus Scopolia,	April 20	March 18
18	Iris reticulata,	March 17	,, 3
19	Leucoium vernum,	February 9	February 6
20	Mandragora officinalis,	March 24	March 26
21	Narcissus Pseudo-Narcissus,	April 11	,, 23
22	,, pumilus,	March 27	,, 10
23	Nordmannia cordifolia,	,, 20	February 20
24	Omphalodes verna,	April 4	March 15
25	Orobus vernus,	March 30	,, 2
26	Rhododendron atrovirens,	February 10	February 4
27	,, Nobleanum,	March 30	,, 14
28	Ribes sanguineum,	,, 31	March 17
29	Scilla bifolia,	,, 19	,, 6
30	,, ,, alba,	,, 20	,, 7
31	,, præcox,	February 12	February 10
32	,, sibirica,	,, 12	,, 14
33	,, taurica,	March 22	March 7
34	Sisyrinchium grandiflorum,	,, 23	,, 2
35	,, ,, album,	,, 23	,, 5
36	Symphytum caucasicum,	April 25	,, 24
37	Symplocarpus fœtidus,	February 23	February 14
38	Tussilago alba,	March 4	,, 18
39	,, fragrans,	February 9	,, 6
40	,, nivea,	March 2	,, 18

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of April 1893.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S.R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·862	57·9	41·4	46·9	44·2	W.	Cir.	8	S.W.	0·000
2	30·100	57·5	36·1	51·3	45·8	S.W.	...	0	...	0·000
3	30·133	52·0	44·2	51·6	47·9	S.W.	Cum.	10	S.W.	0·000
4	30·248	58·6	33·0	47·7	44·5	S.W.	Cum.	8	S.W.	0·000
5	30·168	54·8	37·9	40·3	40·3	N.E.	Cum.	6	N.E.	0·000
6	30·182	53·4	36·2	47·2	45·0	E.	...	0	...	0·000
7	30·416	54·6	38·8	42·2	41·6	N.E.	Cum.	10	N.E.	0·010
8	30·568	50·0	41·7	43·8	42·4	N.E.	Cum.	10	N.E.	0·000
9	30·444	51·9	37·0	43·2	40·8	S.E.	Cum.	3	S.E.	0·000
10	30·336	50·7	32·0	44·2	43·0	E.	Cum.	10	E.	0·010
11	30·398	48·0	41·2	46·2	41·0	E.	Cir.	2	E.	0·000
12	30·360	48·6	31·0	47·7	42·0	N.W.	...	0	...	0·010
13	30·374	57·4	41·0	44·3	39·4	N.E.	Cum.	5	N.	0·000
14	30·180	52·6	35·0	52·7	46·2	W.	...	0	...	0·000
15	29·944	59·0	40·4	50·7	44·8	W.	Cir. St.	8	W.	0·530
16	30·092	56·8	35·2	36·2	35·8	E.	Nim.	10	E.	0·355
17	30·204	40·0	34·9	40·2	37·7	S.E.	Nim.	10	S.E.	0·200
18	29·916	49·3	40·0	49·4	48·6	S.W.	Nim.	10	S.W.	0·225
19	29·900	55·2	44·2	50·3	49·3	E.	Cum.	9	W.	0·030
20	29·970	61·0	46·7	53·5	50·7	E.	Cum.	4	S.	0·000
21	30·232	61·0	44·0	46·0	44·1	N.E.	Cum.	10	N.E.	0·000
22	30·182	51·5	41·0	47·7	45·1	N.E.	...	0	...	0·000
23	30·116	55·0	41·1	44·6	43·4	N.E.	Cum.	10	N.E.	0·000
24	30·106	53·6	36·8	47·9	46·1	N.E.	...	0	...	0·000
25	30·112	61·8	38·0	49·8	47·1	E.	Cir.	4	E.	0·000
26	30·070	54·7	42·8	45·4	44·6	E.	Cum.	10	E.	0·000
27	29·986	56·0	39·3	55·0	50·0	Calm	...	0	...	0·000
28	29·924	61·0	43·0	52·5	46·7	W.	Cir.	2	W.	0·085
29	29·730	59·6	41·8	45.7	43·1	S.W.	Nim.	10	S.W.	0·100
30	29·748	51·8	37·4	50·3	45·4	W.	Cum.	5	W.	0·005

Barometer.—Highest Observed, on the 8th, = 30·568 inches. Lowest Observed, on the 29th, = 29·730 inches. Difference, or Monthly Range, = 0·838 inch. Mean = 30·097 inches.

S. R. Thermometers.—Highest Observed, on the 25th, = 61°·8. Lowest Observed, on the 12th, = 31°·0. Difference, or Monthly Range, = 30°·8. Mean of all the Highest = 54°·5. Mean of all the Lowest = 39°·1. Difference, or Mean Daily Range, = 15°·4. Mean Temperature of Month = 46°·8.

Hygrometer.—Mean of Dry Bulb = 47°·1. Mean of Wet Bulb = 44°·2.

Rainfall.—Number of Days on which Rain fell = 11. Amount of Fall = 1·560 inches. Greatest Fall in 24 hours, on the 15th, = 0·530 inch.

A. D. RICHARDSON,
Observer.

MEETING OF THE SOCIETY,

Thursday, June 8, 1893.

DR. WILLIAM CRAIG, Vice-President, in the Chair.

Mrs. SPRAGUE, Mrs. J. M. BRYDEN, Mrs. W. SANDERSON, Mrs. A. P. AITKEN, and ROBERT JAMES HUNTER, were elected Resident Fellows of the Society.

ROBERT PULLAR, J.P., F.R.S.E., was elected Non-Resident Fellow of the Society.

Mr. DUNN exhibited an ash-stake which, after having been employed for a long period as a support for bushes, had developed buds and leaves.

The CURATOR exhibited pot plants in flower, from the Royal Botanic Garden, of the following:—*Albuca Nelsoni*, *Arthropodium paniculatum*, *Androsace foliosa*, *A. lactea*, *Bulbophyllum Lobbii*, *Disa tripetaloides*, *Calceolaria Kellyana*, *Dianthus alpinus*, *Actinotus Helianthi*, *Houstonia cærulea*, *Myosotis alpestris*, *Oldenlandia Dippeana*, *Saponaria Boissieri*, *Saxifraga cæsia*, *S. squarrosa*, *S. longifolia*, *Sedum spathulifolium*, *Polygonum sphærostachyum*, *Pratia angulata*, *Tradescantia viridescens*.

W. B. BOYD, Esq., Faldonside, sent cut flowers of—*Heuchera sanguinea splendens*, *Linaria origanifolia*, *Cypripedium spectabile*, *Anemone sulphurea*, *Orobus cyaneus*, *Delphinium triste*, *Begonia glaucophylla*, *B. heracleifolia*, *Pentstemon humilis*, *Rubus arcticus* also in fruit, *Symphytum bohemicum*, *Allium subhirsutum*, *Muscari moschatum*, *Ornithogalum narbonense*, *Anigozanthus Manglesii*, *Stylophorum diphyllum*.

Issued November 1893.

Mr. T. CUTHBERT DAY directed the attention of the Society to, and read a summary of, the valuable paper entitled "Contribution to the Chemistry and Physiology of Foliage Leaves," by Mr. Horace T. Brown, F.R.S., and Mr. G. H. Morris, published in the Journal of the Chemical Society.

The following paper was read:—

ON TEMPERATURE AND VEGETATION IN THE ROYAL BOTANIC GARDEN, EDINBURGH, during the month of MAY 1893. By ROBERT LINDSAY, Curator of the Garden.

The past month of May will be remembered as one of the most favourable experienced during recent years. No frost occurred, and vegetation has gone on advancing without any check. The rainfall of May was less than the average, still there was sufficient to prevent plants from suffering through lack of moisture. The foliage of all the ordinary deciduous trees and shrubs is now in perfect condition, being most luxuriant and healthy; varieties having variegated and coloured leaves are unusually rich in colour owing to the large amount of heat and bright sunshine experienced; specially noticeable are the various maples, hollies, yews, biotas, and retinosporas. The flowering of most kinds of ornamental trees and shrubs is above the average in richness and profusion of blossom; hawthorn, horse-chestnut, laburnum, weigelias, and lilac were among the finest and most effective. The lowest night temperature registered at the garden was 33°, which occurred on the 1st of the month. Other low readings were registered on the 2nd, 37°; 7th, 39°; and the 31st, 35°. The lowest day temperature was 49°, on the 2nd, and the highest 76°, on the 19th of the month.

The rock-garden was very attractive during the month from the large number of plants in blossom; 300 species and well-marked varieties opened their first flower in May. Among the most interesting were:—*Anemone alpina sulphurea*, *A. narcissiflora*, *Campanula Allioni*, *C. abietina*, *Cotoneaster thymifolia*, *C, horizontalis*, *Calochortus cæruleus*, *Cytisus decumbens*, *C. Andreanus*, *Anthyllis erinacea*, *A. montana rubra*, *Daphne Cneorum*, *Dianthus Michael Foster*,

Dodecatheon integrifolium, Dryas Drummondi, Edrianthus serpyllifolius, Erica australis rosea, Geranium anemonæfolium, G. Balkanum, Houstonia cærulea, Meconopsis Nepalensis, Ourisia coccinea, Onosma taurica, Lithospermum Gastoni, Veronica Godefroyana, V. linifolia, Vicia argentea, etc.

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during May 1893.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	33°	47°	56°	17th	45°	52°	58°
2nd	37	43	49	18th	44	46	67
3rd	42	47	61	19th	45	62	76
4th	46	54	71	20th	47	56	68
5th	43	57	61	21st	49	60	72
6th	41	54	61	22nd	46	55	73
7th	39	54	63	23rd	47	60	77
8th	41	50	63	24th	46	60	68
9th	40	47	59	25th	48	56	67
10th	40	54	64	26th	44	58	67
11th	44	50	60	27th	49	62	69
12th	49	53	64	28th	42	61	73
13th	51	60	73	29th	44	46	62
14th	46	61	76	30th	43	45	56
15th	47	59	68	31st	35	54	68
16th	44	47	68				

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of May 1893.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours. Max.	Min.	Hygrometer. Dry.	Wet.	Direction of Wind.	Clouds. Kind.	Amount.	Direction.	Rainfall. (Inches.)
		°	°	°	°					
1	29·839	56·0	36·0	50·1	44·8	W.	Cum.	2	W.	0·000
2	29·837	54·8	39·2	44·1	41·7	E.	Cum.	10	E.	0·140
3	30·005	48·4	44·0	47 9	46·8	S.W.	Cum.	10	S.W.	0·010
4	30·157	57·0	45·6	55·6	52·5	W.	...	0	...	0·000
5	30·278	66·7	45 2	52·3	50·1	N.	Cir.	3	W.	0·000
6	30·320	57·8	44·0	48·1	46·8	N.E.	Cum.	10	N.E.	0·000
7	30·381	57·8	42·0	53·8	46·2	E.	...	0	...	0·000
8	30·494	58·8	45·1	49·8	46·8	S.E.	Cum.	8	S.E.	0·000
9	30·456	53·8	45·0	47·5	46·0	E.	Cum.	9	E.	0·000
10	30·378	57·1	42·1	50·3	48·1	W.	...	0	...	0·000
11	30·197	62·7	49·9	60·1	54·5	W.	{ Cir. Cum.	9 1	W. S.W. }	0·020
12	29·971	64·0	51·9	55 1	52·5	S.W.	Cum.	10	S.W.	0·000
13	30·051	61·6	51·3	59·9	54·6	S.W.	Cum.	8	S.W.	0·000
14	29·970	65·7	48·4	59·8	55·2	S.W.	Cum.	10	S.W.	0·000
15	29·988	69·0	48·1	52·8	49·3	E.	Cum.	8	E.	0·000
16	29·831	54·8	46·1	49·0	46·5	E.	Cum.	10	E	0·000
17	29·608	54·0	46·4	50·3	47·9	E.	Cum.	10	E.	0·510
18	29·430	54·0	47·1	48·2	48·1	E.	Nim.	10	E.	0·010
19	29·467	58·6	48·0	59·2	55·2	S.	Cum.	9	S.	0·110
20	29·392	62·5	50 6	56·9	53·9	S.E.	Cum.	10	S.E.	0·225
21	29·594	61·8	50·0	56·8	50·7	S.	Cum.	9	S.	0·090
22	29·746	64·0	45·1	55·7	53·3	S.W.	Cum.	8	S.W.	0·020
23	29·576	65 5	51·0	61·9	57·3	S.W.	Cum.	8	S.W.	0·005
24	29 618	65·6	48·9	59·7	55·1	W.	Cum.	5	W.	0·000
25	29·815	68·5	50·9	58·3	52·2	W.	Cum.	9	W.	0·000
26	30·109	67·3	47·0	55 7	50·9	N.W.	Cum.	10	N.W.	0·000
27	30·153	63 0	44·9	60·2	55·8	N.W.	Cum.	9	N.W.	0·000
28	30·094	68·8	47·0	61·2	56·9	W.	Cum.	10	W.	0·330
29	30·078	69·0	46·7	46·9	46·3	E.	Nim.	10	E.	0·035
30	30·076	52·7	45·3	44·6	44·0	N.W.	Cum.	9	N.W.	0·000
31	29·985	55·9	39·3	52·3	47·3	N.W.	Cum.	9	N.W.	0·000

Barometer.—Highest Observed, on the 8th, = 30·494 inches. Lowest Observed, on the 20th, = 29·392 inches. Difference, or Monthly Range, = 1·102 inch. Mean = 29·961 inches.

S. R. Thermometers.—Highest Observed, on the 15th and 29th, = 69°·0. Lowest Observed, on the 1st, = 36°·0. Difference, or Monthly Range, = 33°·0. Mean of all the Highest = 60°·6. Mean of all the Lowest = 46°·2. Difference, or Mean Daily Range, = 14°·4. Mean Temperature of Month = 53°·4.

Hygrometer.—Mean of Dry Bulb = 53°·7. Mean of Wet Bulb = 50°·2.

Rainfall.—Number of Days on which Rain fell = 12. Amount of Fall = 1·505 inch. Greatest Fall in 24 Hours, on the 17th, = 0·510 inch.

A. D. RICHARDSON,
Observer.

MEETING OF THE SOCIETY,

Thursday, July 13, 1893.

Dr. William Craig, Vice-President, in the Chair.

The Curator exhibited the following plants from the Royal Botanic Garden:—*Azolla filiculoides* in fruit, *Androsace glacialis, Anigozanthus rufa, Burbidgea nitida, Calceolaria Kellyana, Campanula Barrelierii, C. pumila, C. retrorsa, Disa grandiflora, D. racemosa, Erythræa diffusa, Dianthus neglectus roseus, Dicksonia antarctica* seedling from spores ripened out of doors in Arran, *Gentiana purpurea, Genista aspalathoides, Helianthemum amabile fl. pl., Micromeria piperella, Nertera depressa, Primula Heerii, P. Poissonii, Xylophylla montana, Silene Schaftii, Tradescantia iridescens.*

The following paper was read:—

On Temperature and Vegetation at the Royal Botanic Garden, Edinburgh, during the month of June 1893. By Robert Lindsay, Curator of the Garden.

The past month of June was remarkable for the excessive heat and dryness which prevailed. The continued want of rain having lasted throughout nearly the whole of the past spring, the marvel is that its effects have not been more serious on vegetation. The lowest reading of the thermometer during June was 40°, which was registered on the 2nd; on the night of the 16th the thermometer did not fall below 62°. The lowest day temperature was 50°, on the 23rd, and the highest 89°, on the 18th of the month. Hardy herbaceous plants flowered freely, but went quickly past owing to the drought; the earlier flowering kinds have ripened their seeds abundantly.

Issued November 1893.

On the rock-garden fewer plants came into flower this month than for any June during the last eleven years, the largest number having blossomed this year in May. In all 294 species and varieties came into flower during the month. The most interesting were:—*Anemone palmata, Antirrhinum asarinum, Arnica montana, Asperula nitida, Cyananthus lobatus, Calochortus luteus, Celmisia spectabilis, Coronilla iberica, Crambe cordifolia, Campanula garganica alba, Craspedia Richei, Dianthus alpinus, D. neglectus, D. superbus, Dictamnus tauricus, Epilobium latifolium, Eriogonum aureum, Galax aphylla, Gentiana alba, G. lutea, Gillenia trifoliata, Hypericum Nummularia, Kniphofia caulescens, Linaria origanifolia, Lilium Kramerii, Meconopsis Wallichii, Mimulus Jeffreyanus, M. cardinalis, Potentilla nitida atrorubens, Rhododendron ferrugineum album, Ranunculus parnassifolius, Saponaria cæspitosa, Saxifraga cæsia major, S. fimbriata, Tropæolum polyphyllum, Veronica Bidwillii, V. cupressoides, V. rakaiensis.*

Readings of exposed Thermometers at the Rock-Garden of the Royal Botanic Garden, Edinburgh, during June 1893.

Date.	Minimum.	9 A.M.	Maximum.	Date.	Minimum.	9 A.M.	Maximum.
1st	45°	57°	68°	16th	46°	79°	85°
2nd	40	60	69	17th	62	73	86
3rd	42	62	70	18th	54	79	89
4th	45	63	76	19th	57	70	85
5th	42	62	66	20th	49	62	71
6th	44	58	70	21st	46	62	71
7th	51	67	76	22nd	49	59	63
8th	51	55	66	23rd	44	47	50
9th	47	50	64	24th	45	53	66
10th	45	59	71	25th	45	59	69
11th	48	65	75	26th	41	56	69
12th	46	65	67	27th	47	61	72
13th	47	50	68	28th	55	62	74
14th	51	58	69	29th	53	60	68
15th	46	52	77	30th	44	68	74

Meteorological Observations taken at Royal Botanic Garden, Edinburgh, during the Month of June 1893.

Distance from Sea, 1 mile. Height of Cistern of Barometer above Mean Sea-Level, 71·5 feet. Hour of Observation, 9 A.M.

Days of the Month.	Barometer, corrected and reduced to 32°. (Inches.)	Thermometers, protected, 4 feet above grass. S. R. Thermometers for preceding 24 hours.		Hygrometer.		Direction of Wind.	Clouds.			Rainfall. (Inches.)
		Max.	Min.	Dry.	Wet.		Kind.	Amount.	Direction.	
		°	°	°	°					
1	29·913	62·8	48·4	60·1	54·1	N.W.	Cum.	8	N.W.	0·000
2	29·818	62·2	41·2	58·1	50·6	W.	Cum.	1	W.	0·000
3	29·788	64·6	44·7	58·1	52·7	E.	Cir.	2	S.W.	0·000
4	29·926	70·8	46·9	63·0	56·1	S.W.	Cir. Cum.	4	S.W.	0·030
5	30·166	65·3	45·7	62·1	54·7	N.W.	...	0	...	0·000
6	30·217	65·6	48·0	57·0	53·8	S.W.	Cum.	10	S.W.	0·060
7	30·289	64·4	55·1	64·3	59·9	S.W.	Cum.	6	S.W	0·000
8	30·336	67·7	50·9	53·9	53·0	E.	Cum. St.	10	E.	0·010
9	30·314	59·0	49·7	50·3	49·9	E.	St.	10	E.	0·000
10	30·323	57·8	49 7	57·2	53·0	E.	Cum.	10	N.W.	0·000
11	30·207	64·7	50·3	60·3	55·6	E.	...	0	...	0·000
12	30·094	67·0	44·3	60·0	54·0	S.	...	0	...	0·000
13	30·006	63·8	50·9	51·9	50·3	N.E.	Cum. St.	10	N.E.	0·000
14	29·931	62·0	50·7	57·3	53·8	N.E.	Cum	2	N.E.	0·000
15	29·964	64 8	50·7	52·0	50·9	N.W.	Cum. St.	10	N.E.	0·000
16	30·008	69·8	50·7	69·9	62·2	W.	Cir.	2	W.	0·000
17	30·230	82·6	61·9	70·0	64·0	N.W.	Cum.	5	W.	0·000
18	30·239	80·0	54 2	72·7	65·2	N.W.	...	0	...	0·000
19	29·964	85·8	57·9	67·0	63·0	W.	Cum.	6	W.	0·000
20	29·831	79·8	51·9	58·9	51·3	E.	Cum.	9	N.W.	0·000
21	29·801	64·0	51·0	58·5	52 9	E.	Cum.	6	N.	0·000
22	29·507	65·6	47·1	58·1	54·1	W.	Cum.	10	W.	0·760
23	29·242	59·8	47·5	49·7	49·0	N.E.	Nim.	10	N.E.	0·620
24	29·358	54·8	48·4	54·9	50·8	N.E.	Cum.	10	N.E.	0·000
25	29 531	61·7	46·7	57·5	52·3	N.W.	Cum.	9	N.W.	0·100
26	29·673	65·8	44·0	59·6	51·3	N.W.	Cum.	8	N.W.	0·130
27	29·343	63 8	52·8	60·1	57·4	S.	Cum.	9	S.	0·150
28	29·254	67·0	58·4	65 3	58·8	E.	Cum.	10	S.W.	0·065
29	29·605	67·8	55·9	62·3	57·7	W.	Cum.	10	W.	0·000
30	30·074	67·8	46·9	63·4	55·9	W.	...	0	...	0·000

Barometer.—Highest Observed, on the 8th, = 30·336 inches. Lowest Observed, on the 23rd, = 29·242 inches. Difference, or Monthly Range, = 1·094 inch. Mean = 29·898 inches.

S. R. Thermometers.—Highest Observed, on the 19th, = 85°·8. Lowest Observed, on the 2nd, = 41°·2. Difference, or Monthly Range, = 44°·6. Mean of all the Highest = 66°·6. Mean of all the Lowest = 50°·1. Difference, or Mean Daily Range, = 16°·5. Mean Temperature of Month = 58°·3.

Hygrometer.—Mean of Dry Bulb = 59°·8. Mean of Wet Bulb = 54°·9.

Rainfall.—Number of Days on which Rain fell = 9. Amount of Fall = 1·925 inch. Greatest Fall in 24 Hours, on the 22nd, = 0·760 inch.

A. D. RICHARDSON,
Observer.

APPENDIX.

THE BOTANICAL SOCIETY OF EDINBURGH.

Founded 1836.

I.—GENERAL VIEWS AND OBJECTS OF THE SOCIETY.

THE attention of the Society is turned to the whole range of Botanical Science, together with such parts of other branches of Natural History as are more immediately connected with it. These objects are cultivated :—

1. By holding Meetings for the interchange of botanical information,—for the reading of original papers or translations, abstracts or reviews of botanical works, regarding any branch of botanical knowledge, practical, physiological, geographical, and palæontological,—and the application of such knowledge to Agriculture and the Arts.

2. By publishing annually *Proceedings and Transactions*, including a List of Members and Donations.

3. By the formation in Edinburgh of an Herbarium of Foreign and British Plants, and of a Library and Museum for general consultation and reference.

4. By printing from time to time Catalogues of Plants, with the view of facilitating the study of their geographical distribution, and furthering the principle of exchange.

5. By making Botanical Excursions both in the neighbourhood of Edinburgh and to distant parts of Britain.

6. By appointing Local Secretaries, from amongst the Members of the Society, from whom, in their respective districts, all information regarding the Society's objects and proceedings may be obtained.

II.—LAWS OF THE SOCIETY.

CHAPTER I.—FUNDAMENTAL LAWS.

1. The Society shall be denominated "THE BOTANICAL SOCIETY OF EDINBURGH."

2. The object of the Society shall be the advancement of Botanical Science, by means of periodical meetings, publications, correspondence, and interchange of specimens amongst its Members.

3. The Society shall be open to Ladies and Gentlemen, and shall consist of Honorary, Resident, Non-Resident, and Corresponding Members, who shall have the privilege of denominating themselves Fellows of the Society; of Lady Members elected under the rule Chapter IV., Section 6 hereof, and of Associates elected under the rule Chapter IV., Section 5 hereof.

Chapter II.—Ordinary Meetings.

1. A Meeting of the Society shall be held on the second Thursday of every month, from November to July inclusively.

2. Intimation of all papers to be brought before the Society must be given to the Secretary and submitted to the Council ten days at least previous to the Meeting at which they are to be read.

3. Any Member may transmit to the Society Papers and Communications, which, if approved of by the Council, may be read by the author, or, in his absence, by the President or Secretary at any of the Ordinary Meetings.

4. The following order of business shall be observed:—

PRIVATE BUSINESS.

1. Chair taken.
2. Minutes of Private Business of preceding Meeting read.
3. Report of Council read.
4. Applications for Admission read.
5. Members proposed at preceding Meeting balloted for.
6. Motions intimated at previous Meetings discussed.
7. New Motions intimated.
8. Miscellaneous Business.
9. Society adjourned.

PUBLIC BUSINESS.

1. Chair taken.
2. Laws signed by New Members.
3. Minutes of Public Business of preceding Meeting read.
4. Papers and Communications for next Meeting announced.
5. Specimens, Books, etc., presented.
6. Communications and Papers read.
7. Society adjourned.

Chapter III.—Extraordinary Meetings.

An Extraordinary Meeting of the Society may be called at any time, by authority of the Council, on the requisition of three or more Resident Fellows.

Chapter IV.—Admission of Members.

SECTION I.—HONORARY FELLOWS.

1. The Honorary Fellows shall be limited to six British and twenty-five Foreign,—by British, being understood British subjects, whether resident in the British Islands or not.

2. The Council shall have the privilege of proposing Honorary Fellows,—the names of the gentlemen proposed being always stated in the Billet calling the Meeting at which they are to be balloted for. The election to be determined by a majority of at least two-thirds of the votes, provided fifteen Fellows are present and vote.

3. Any Fellow may submit to the Council the names of individuals whom he would wish proposed as Honorary Fellows; and should the Council decline to bring these forward, he may demand that they be balloted for.

4. Honorary Fellows shall be entitled to all the privileges of Resident Fellows, and shall receive copies of the *Transactions* free of charge.

SECTION II.—RESIDENT FELLOWS.

1. A candidate for admission into the Society, as a Resident Fellow, must present an application, with a recommendation annexed, signed by at least two Resident Fellows. The application shall be read at the proper time during private business, and at the next Ordinary Meeting shall be determined by a majority of at least two-thirds of the votes, provided fifteen Fellows are present and vote.

2. Resident Fellows shall, on admission, sign the Laws, and pay the sum of Fifteen Shillings to the funds of the Society; and shall contribute Fifteen Shillings annually thereafter at the November Meeting. Resident Fellows are entitled to receive the *Transactions* provided their subscriptions are paid.

3. Resident Fellows may at any time compound for their annual contributions by payment of Six Guineas. They shall be entitled to receive the *Transactions* yearly as published.

4. Resident Fellows leaving Edinburgh may be enrolled as Non-Resident Fellows, if they have paid by annual subscriptions the sum of Six Guineas, and have also paid any arrears due at their departure. By a further payment of Two Guineas they shall be entitled to receive the *Transactions.*

5. Fellows who are not in arrear in their subscriptions, and in their payments for the *Transactions*, will receive copies of the latter provided they apply for them within two years after publication. Fellows not resident in Edinburgh must apply for their copies either personally, or by an authorized agent, to the Secretary or Treasurer.

6. The Society shall from time to time adopt such measures regarding Fellows in arrears as shall be deemed necessary.

SECTION III.—NON-RESIDENT FELLOWS.

1. Any person not residing in Edinburgh may be balloted for as a Non-Resident Fellow, on being recommended by two Fellows of the Society, and paying a contribution of Three Guineas. From such no annual payment is required.

2. Non-Resident Fellows, by payment of Two Guineas

additional, shall be entitled to receive the *Transactions* yearly as published.

3. Non-Resident Fellows wishing to become Resident, must intimate their intention to the Secretary, who shall put them on the Resident list. They shall pay the annual subscriptions of Fifteen Shillings, or Three additional Guineas, or One Guinea if they have compounded for the *Transactions*.

4. Non-Resident Fellows must arrange with the Assistant-Secretary for the transmission of their copies of the *Transactions*; and they are requested to acknowledge receipt. Billets of the Meetings may, if desired, be also obtained.

5. Non-Resident Fellows coming to Edinburgh shall, for a period of two months, be entitled to attend the Meetings of the Society, and participate in the other privileges of Resident Fellows; after which, should they remain longer, they must pay the usual annual subscription of Resident Fellows, unless they have compounded by payment of Six Guineas.

SECTION IV.—CORRESPONDING MEMBERS.

1. Any person residing abroad may be balloted for as a Corresponding Member, on the recommendation of the Council.

SECTION V.—ASSOCIATES.

1. The Society shall have power to elect by ballot, on the recommendation of the Council, Associates from those who, declining to become Resident or Non-Resident Members, may have acquired a claim on the Society by transmitting specimens or botanical communications. Associates have no vote in elections or in the transaction of the business of the Society, are not entitled to receive copies of the *Transactions*, and have no interest in the property of the Society.

SECTION VI.—LADY MEMBERS.

1. Any Lady, whether Resident or Non-Resident, may become, on the recommendation of the Council, a Member for life on payment of a single contribution of Two Guineas, or may be elected and continue a Member on payment annually of a subscription of Ten Shillings; but Lady Members elected under this rule shall not be entitled to receive copies of the *Transactions*, shall have no voice in the management of the Society, nor any interest in the property thereof.

Note.—Diplomas may be procured by Fellows from the Acting Secretary, the sum payable being Five Shillings, and Two Shillings for a tin case. But no Fellow shall be entitled to receive a Diploma until his contributions have amounted to Three Guineas.

CHAPTER V.—OFFICE-BEARERS.

1. The Office-Bearers of the Society may be chosen from the Resident or Non-Resident Fellows, and they shall consist of a President, four Vice-Presidents, ten Councillors, an Honorary Secretary, an Assistant Secretary, a Foreign Secretary, and a

Treasurer, who shall be elected annually at the Ordinary Meeting in November. If a Non-Resident Fellow be elected an Office-Bearer, he must become a Resident Fellow, in conformity with Section III., Law 3.

2. The Council shall annually prepare a list of Fellows whom they propose to nominate as Office-Bearers for the ensuing year. This list shall be printed and put into the hands of Fellows along with the Billet of the November Meeting; and Fellows shall vote by putting these lists into the ballot-box, with any alterations they may think proper to make. The lists shall not be signed. Every Fellow present at the Meeting is entitled to vote.

3. All the Office-Bearers may be re-elected, except the two senior Vice-Presidents and the three senior Councillors, who shall not be re-eligible to the same offices till after the interval of one year.

4. These Office-Bearers shall form the Council for the general direction of the affairs of the Society. Three to be a quorum.

5. The Council shall nominate annually an Auditor and an Artist, to be recommended to the Society.

6. The Council shall appoint annually at the December Meeting five of their number, including the President and Honorary Secretary, to superintend the printing of the *Transactions* of the Society.

7. The Council may at any time be called upon by the President, Vice-Presidents, or Secretaries, to meet with them for the transaction of private business.

8. The Council shall hold a Meeting for business on the second Tuesday before each General Meeting.

Chapter VI.—The President and Vice-Presidents.

1. It shall be the duty of the President and Vice-Presidents when in the chair, and of the Chairman in their absence, to conduct the business of the Society according to the order of the business laid down in Chapter II., Law 4, and to attend carefully to the enforcement of the Laws of the Society, and to signing the Minutes. The Chairman shall have a vote and a casting vote.

Chapter VII.—The Secretaries.

1. The Honorary Secretary, with the aid of the Assistant-Secretary, shall give intimation of all General and Committee Meetings, shall Minute their proceedings in Books to be kept for the purpose, and shall conduct all the Society's Correspondence in Britain. He shall also take charge of all Donations of Plants and Books, and shall see them deposited in the Herbarium and Library, in conformity with any arrangements made by the Society with Government.

2. The Foreign Secretary shall have charge of all the Foreign Correspondence.

Note.—Agreeably to an Act of the Town Council of the City of Edinburgh, dated January 8, 1839, the Professor of Botany in the University of Edinburgh is constituted Honorary Curator *ex officio*, with free access to the Society's Collection, whether a Member of the Society or not.

Chapter VIII.—The Treasurer and Auditor.

1. The Treasurer, subject to the inspection of the Council, shall receive and disburse all money belonging to the Society, collecting the money when due, and granting the necessary Receipts. His Accounts shall be audited annually by the Auditor appointed by the Society.

2. It shall be the duty of the Treasurer to place all money belonging to the Society in one of the Chartered Banks of this City, unless the same shall have been ordered by the Society to be otherwise invested; and he shall never keep more than Ten Pounds of the Funds of the Society in his hands at a time. The Bank Account shall be kept in the name of the Society, and all drafts thereon shall be signed by the Treasurer.

3. The Treasurer shall, at the November Meeting, submit a certified Statement of the Receipts and Expenditure of the past year, with the Auditor's Report thereon.

Chapter IX.—Visitors.

Each Fellow shall have the privilege of admitting one Visitor to the Ordinary Meetings of the Society at the close of the private business.

Chapter X.—Additional Law.

In the event of any Member acting in such a way as shall seem to the Fellows of the Society to be detrimental to its interests, the Council may recommend that the name of such Member be deleted from the roll. The recommendation shall be brought before the Society at its first Ordinary Meeting. It shall be finally decided at the immediately succeeding Meeting by ballot. If confirmed by a majority of two-thirds of the votes of at least fifteen Fellows, the name of such person shall be deleted from the roll of membership, and all his privileges connected with the Society shall be forfeited.

Chapter XI.—Making and Altering Laws.

Any motion for the alteration of Existing Laws, or the enactment of new ones, shall lie over till the second Ordinary Meeting, and shall then be determined by a majority of at least two-thirds of the votes, provided fifteen Fellows are present and vote. The motion must be intimated to the Council, and shall be printed in the Billet calling the Meeting at which it is to be brought forward, and also in the Billet of the Meeting at which it is to be discussed.

ROLL

OF

THE BOTANICAL SOCIETY OF EDINBURGH.

Corrected to November 1893.

Patron:

HER MOST GRACIOUS MAJESTY THE QUEEN.

HONORARY FELLOWS.

Date of Election.

April 1863. His Royal Highness The PRINCE of WALES, K.G., Hon. F.R.S. L. & E.

Nov. 1863. His Royal Highness The DUKE of EDINBURGH, K.G., K.T., LL.D. Edin.

Dec. 1877. His Majesty Oscar II. KING of SWEDEN.

BRITISH SUBJECTS (limited to six).

Jan. 1866. Babington, Charles Cardale, M.A., F.R.S., F.L.S., F.S.A., *Fellow of St. John's College and Professor of Botany, Cambridge;—Non-Resident Fellow, May* 1836.

Dec. 1890. Cleghorn, Hugh F. C., M.D., LL.D., F.R.S.E., F.L.S., *Strathvithie, St. Andrews;—Resident Fellow, June* 1838.

Nov. 1888. Dyer, William Turner Thiselton, M.A., C.M.G., C.I.E., F.R.S., *Director, Royal Gardens, Kew.*

Jan. 1866. Hooker, Sir Joseph Dalton, M.D., K.C.S.I., C.B., D.C.L. Oxon., LL.D. Cantab., F.R.S., F.L.S., F.G.S., *The Camp, Sunningdale, Berks.*

Dec. 1882. Oliver, Daniel, F.R.S., F.L.S., *Kew;—Non-Resident Fellow, Nov.* 1851.

Jan. 1886. Spruce, Richard, Ph.D., *Coneysthorpe, Malton, Yorkshire;—Non-Resident Fellow, Dec.* 1841.

FOREIGN (limited to twenty-five).

Jan. 1866. Agardh, Jakob Georg, For. F.L.S., *Emeritus Professor of Botany, Lund.*

Jan. 1866. Baillon, Dr. Henri Ernest, For. F.L.S., *Professor of Natural History in the Faculty of Medicine, Paris.*

Dec. 1877. Cohn, Dr. Ferdinand, For. F.L.S., *Professor of Botany in the University, and Director of the Botanical Museum and Physiological Institute, Breslau;—Corresponding Fellow, Jan.* 1873.

May 1891. Cornu, Dr. Max, *Director of the Jardins des Plantes, Paris.*

Dec. 1885. Delpino, Dr. Frederico, *Professor of Botany in the University, and Director of the Botanic Garden, Bologna;—Corresponding Fellow, Jan.* 1873.

Dec. 1885. Duchartre, Pierre, Membre de l'Institut, For. F.L.S., *Professor of Botany, Paris;—Corresponding Fellow, Jan.* 1873.

May 1891. Engler, Dr. Adolf, For. F.L.S., *Professor of Botany in the University, and Director of the Royal Botanic Garden and Museum, Berlin;—Corresponding Fellow, Jan.* 1886.

Date of Election.

Dec. 1892. GOEBEL, Dr. K. E., For. F.L.S., *Professor of Botany in the University, and Director of the Botanic Garden, Munich.*
Dec. 1885. GRAND'EURY, *St. Etienne.*
May 1891. HARTIG, Dr. ROBERT, For. F.L.S., *Professor of Forestry in the University, Munich.*
Dec. 1885. HILDEBRAND, Dr. F., *Professor of Botany in the University, and Director of the Botanic Garden, Freiburgi, Br.*
Dec. 1878. LANGE, Dr. JOHANNES MARTIN, For. F.L.S., *Professor of Botany, Copenhagen;—Corresponding Fellow, Dec.* 1847.
Jan. 1874. MUELLER, Baron FERDINAND VON, M.D., K.C.M.G., F.R.S., For. F.L.S., *Government Botanist, Melbourne.*
Dec. 1877. NYLANDER, Dr. GUILLAUME, For. F.L.S., *Paris;—Corresponding Fellow, Jan.* 1865.
Dec. 1869. PRINGSHEIM, Dr. NATHAN, For. F.L.S., *Berlin;—Corresponding Fellow, Jan.* 1866.
Jan. 1873. SACHS, Dr. JULIUS VON, For. F.R.S., For. F.L.S., *Professor of Botany in the University, and Director of the Botanic Garden, Würzburg;—Corresponding Fellow, Dec.* 1869.
Dec. 1885. SCHWENDENER, Dr. S., For. F.L.S., *Professor of Botany in the University, Berlin.*
Dec. 1892. SOLMS-LAUBACH, GRAF. H. ZU., For. F.L.S., *Professor of Botany in the University, and Director of the Botanic Garden, Strasburg.*
Feb. 1876. STRASBURGER, Dr. EDOUARD, For. F.R.S., For. F.L.S., *Professor of Botany in the University, and Director of the Botanic Garden, Bonn;—Corresponding Fellow, Jan.* 1873.
Dec. 1885. TIEGHEM, PHILLIPE VAN, Membre de l'Institut, For. F.L.S., *Professor of Botany, Paris;—Corresponding Fellow, April* 1877.
Dec. 1885. WARMING, Dr. EUGENE, For. F.L.S., *Professor of Botany in the University, and Director of the Botanic Garden, Copenhagen.*

RESIDENT AND NON-RESIDENT FELLOWS.

No distinguishing mark is placed before the name of Resident Fellows who contribute annually and receive Publications.

* *Indicates Resident Fellows who have compounded for Annual Contribution and receive Publications.*

† *Indicates Non-Resident Fellows who have compounded for Publications.*

‡ *Indicates Non-Resident Fellows who do not receive Publications.*

Date of Election.

Dec. 1888. *Aitchison, J. E. T., M.D., LL.D., C.I.E., F.R.S., care of Messrs. Grindlay, Groom, & Co., *Bombay.*
Jan. 1871. *Aitken, A. P., M.A., D.Sc., F.R.S.E., 57 *Great King Street.*—FOREIGN SECRETARY.
June 1893. Aitken, Mrs. A. P., 57 *Great King Street.*
Nov. 1884. †Alexander, J., *Forest Department, Galle, Ceylon.*
June 1875. *Alison, Rev. G., *Kilbarchan, Paisley.*
April 1877. ‡Allan, Francis J., M.D., 1 *Dock Street, London, E.*
Dec. 1855. ‡Allman, G. J., F.R.SS. L. & E., F.L.S., *Athenæum Club, London.*
June 1852. ‡Anderson, John, M.D., F.L.S., 71 *Harrington Gardens, London, S.W.*
Feb. 1876. *Anderson, Rev. Thomas, 44 *Findhorn Place.*
Dec. 1866. *Archibald, John, M.B., C.M., F.R.C.S.E., 2 *The Avenue, Beckenham, Kent.*
Dec. 1850. ‡Armitage, S. H., M.D., 9 *Huntris Row, Scarborough.*
Dec. 1888. †Bailey, Colonel Fred., R.E., *Conservator of Forests*, 6 *Drummond Place.*
May 1872. *Balfour, I. Bayley, Sc.D., M.D., F.R.S., F.L.S., F.G.S., *Queen's Botanist, Professor of Botany, and Keeper of the Royal Botanic Garden, Inverleith House.*—CURATOR.
Dec. 1868. *Balfour, Thomas Alex. Goldie, M.D., F.R.S.E., 51 *George Square.*
Dec. 1863. †Barnes, Henry, M.D., F.R.S.E., 6 *Portland Square, Carlisle.*
July 1880. ‡Barty, Rev. Thomas, M.A., *The Manse, Kirkcolm.*
July 1848. *Bayley, George, W.S., 7 *Randolph Crescent.*
Feb. 1857. *Bell, John M., W.S., *East Morningside House.*
May 1891. *Berwick, Thomas, 56 *North Street, St. Andrews.*

Date of Election.

April 1857. ‡Beveridge, Jas. S., L.R.C.P. and S., 9 *Spring Gardens, London, S.W.*
Dec. 1879. *Bird, George, 24 *Queen Street.*
June 1850. ‡Birdwood, Sir George, M.D., *India Office.*
July 1870. *Black, James Gow, Sc.D., *Professor of Chemistry, University of Otago, New Zealand.*
May 1888. *Bonnar, William, 8 *Spence Street.*
Dec. 1886. *Bower, F. O., M.A., D.Sc., F.R.S., F.L.S., *Professor of Botany, University of Glasgow,* 45 *Kersland Street, Hillhead, Glasgow.*—PRESIDENT.
Jan. 1871. *Boyd, W. B., *of Faldonside, Melrose.*
Feb. 1870. †Bramwell, John M., M.B., C.M., *Burlington House, Goole, Yorkshire.*
Jan. 1837. ‡Branfoot, J. H., M.D., *West Indies.*
April 1857. †Brown, George H.W., *Victoria, Vancouver Island.*
June 1840. †Brown, Isaac, *Brantholme, Kendal.*
Dec. 1890. Brown, Richard, C.A., 23 *St. Andrew Square.*—TREASURER.
Dec. 1860. ‡Brown, Robert, Ph.D., F.L.S., *Fersley, Rydal Road, Streatham, London, S.W.*
Nov. 1882. †Brown, William, *Earlsmill, Forres.*
Mar. 1850. ‡Brown, William, M.D., *Cape of Good Hope.*
June 1893. Bryden, Mrs. J. M., 72 *Great King Street.*
Dec. 1864. Buchan, Alexander, M.A., LL.D., F.R.S.E, *Sec. Scot. Met. Soc.,* 72 *Northumberland Street.*
Dec. 1878. *Buchanan, James, *Oswald Street.*
April 1855. ‡Burnett, Charles John, *Aberdeen.*
May 1839. ‡Burslem, Willoughby Marshall, M.D., *Bournemouth, Hants.*
Feb. 1882. Caird, Francis M., M.B., C.M., 21 *Rutland Street,*
Dec. 1836. ‡Carnegie, W. F. Lindsay, *Kinblethmont.*
Dec. 1858. †Carruthers, William, F.R.S., F.L.S., *British Museum of Natural History, South Kensington, London.*
Nov. 1842. ‡Carter, James, M R.C.S., *Cambridge.*
Feb. 1848. Christison, Sir Alexander, Bart., M.D., 40 *Moray Place.*
Mar. 1893. Christison, Lady, 40 *Moray Place.*
April 1848. Christison, David, M.D., 20 *Magdala Crescent.*
June 1873. *Clark, T. Bennet, 15 *Douglas Crescent.*
Dec. 1854. ‡Clay, Robert H., M.D., 4 *Windsor Villas, Plymouth.*
Dec. 1856. †Cleland, John, M.D., F.R.S., *Professor of Anatomy, University of Glasgow.*
May 1861. ‡Coldstream, Wm., B.A., B.Sc., *Commissioner, Punjab, India.*
April 1850. ‡Collingwood, Cuthbert, M.A., M.B., F.L.S., M.R.C.P., 69 *Great Russell Street, London, W.C.*
Dec. 1868. †Collins, James, 13 *Napier Street, Deptford, London.*
April 1865. †Cooke, M. C., M.A., LL.D., 146 *Junction Road, London, N.*
Feb. 1870. †Cowan, Charles W., *Valleyfield, Penicuik.*
Dec. 1860. *Craig, Wm., M.D., C.M., F.R.C.S.E., F.R.S.E., 71 *Bruntsfield Place.*
Feb. 1874. †Crawford, William Caldwell, 1 *Lockharton Gardens, Slateford.*
Nov. 1881. Croom, J. Halliday, M.D., F.R.C.P.E., 25 *Charlotte Square.*
July 1871. *Davies, Arthur E., Ph.D., F.L.S., *Tweed Bank, West Savile Road.*
Feb. 1863. ‡Dawe, Thos. Courts, *St. Thomas, Launceston.*
April 1862. ‡Dawson, John, *Witchhill Cottage, Kinnoul, Perth.*
Dec. 1892. Day, T. Cuthbert, 36 *Hillside Crescent.*
Mar. 1841. ‡Dennistoun, John, *Greenock.*
Jan. 1869. ‡Dickinson, E. H., M.D., M.A., 162 *Bedford St. South, Liverpool.*
June 1848. ‡Dobie, W. M., M.D., *Chester.*
Jan. 1860. †Dresser, Christopher, Ph.D., F.L.S., *Wellesley Lodge, Sutton, Surrey.*
July 1869. *Drummond, W. P., 5 *Granton Road.*
Dec. 1859. †Duckworth, Sir Dyce, M.D., 11 *Grafton Street, Bond Street, London, W.*
June 1851. ‡Duff, Alex. Groves, M D., *New Zealand.*
Dec. 1865. *Duncanson, J. J. Kirk, M.D., C.M., F.R.S.E , 22 *Drumsheugh Gardens.*
Dec. 1870. Dunn, Malcolm, *The Palace Gardens, Dalkeith.*
Feb. 1871. ‡Dupuis, Nathan Fellowes, M.A., *Professor of Mathematics, Queen's College, Kingston, Canada.*
Dec. 1869. †Duthie, J. F., B.A., F.L.S., *Superintendent of the Botanic Gardens, Saharunpore, N.W.P., India.*

Date of Election.	
Feb. 1891.	Edington, Alexander, M.B., C.M., *Cape of Good Hope.*
Nov. 1885.	Elliot, G. F. Scott, M.A., B.Sc., F.L.S., *Newton, Dumfries.*
Dec. 1839.	‡Elliot, Robert, care of W. E. Lockhart, Esq. *of Cleghorn, Lanark.*
Jan. 1883.	*Evans, Arthur H., M.A., 9 *Harvey Road, Cambridge.*
Mar. 1890.	Ewart, J. Cossar, M.D., F.R.S.E., *Professor of Natural History, University.*
Dec. 1860.	†Farquharson, Rev. James, D.D., *Selkirk.*
Dec. 1858.	†Fayrer, Sir Joseph, M.D., K.C.S.I., F.R.SS. L. & E., 53 *Wimpole Street, Cavendish Square, London.*
April 1887.	†Fingland, James, *Thornhill, Dumfries.*
June 1838.	Fleming, Andrew, M.D., F.R.S.E., 3 *Napier Road.*
Nov. 1840.	‡Flower, Thomas Bruges, F.L.S., M.R.C.S., 9 *Beaufort Buildings West, Bath.*
Nov. 1861.	†Foggo, R. G., *Invercauld, Aberdeenshire.*
Dec. 1861.	‡Foote, Harry D'O., M.D., *Crofts House, Rotherham, Yorkshire.*
Dec. 1887.	Forsyth, John M., *Woburn, Bedfordshire.*
Mar. 1870.	‡Foss, Robert W., M.B., C.M., *Stockton-on-Tees, Durham.*
July 1885.	Foulis, James, M.D., F.R.C.P.E., 34 *Heriot Row.*
July 1860.	†Fox, Charles H., M.D., *Brislington House, near Bristol.*
Feb. 1873.	*France, Charles S., care of Cardno & Darling, *Seedsmen, Aberdeen.*
Nov. 1879.	Fraser, Alexander, *Canonmills Lodge.*
June 1874.	Fraser, Rev. James, M.A., *The Manse, Colvend, Dalbeattie.*
June 1836.	‡Fraser, James A., M.D., *Cape Town.*
July 1872.	*Fraser, John, M.D., 19 *Strathearn Road.*
Dec. 1865.	†Fraser, John, M.A., M.D., *Chapel Ash, Wolverhampton.*
Dec. 1855.	*Fraser, Patrick Neill, *Rockville, Murrayfield.*
Mar. 1862.	Fraser, Thomas R., M.D., F.R.S., *Professor of Materia Medica,* 13 *Drumsheugh Gardens.*
April 1848.	‡French, J. B., *Australia.*
Feb. 1871.	Galletly, Alexander, *Curator, Museum of Science and Art.*
Mar. 1871.	*Gamble, James Sykes, M.A., F.L.S., *Conservator of Forests, Dehra Dún, North-West Provinces, India.*
Jan. 1866.	*Gayner, Charles, M.D., F.R.S.E., *Oxford.*
Jan. 1881.	Geddes, Patrick, F.R.S.E., *Professor of Botany, University College, Dundee, University Hall, Ramsay Gardens.*
May 1874.	‡Geikie, Sir Archibald, LL.D., F.R.SS. L. & E., *Director General, H.M. Geological Survey,* 4 *Jermyn Street, London.*
Jan. 1887.	*Gibson, A. H., 5 *Crawfurd Road.*
Nov. 1836.	†Gordon, Rev. George, LL.D., *Birnie, Elgin.*
Dec. 1836.	‡Gough, The Viscount George S., F.R.S., M.R.I.A., *Lougheutra Castle, Gort, Galway.*
Jan. 1889.	*Grieve, James, *Pilrig Nurseries.*
Feb. 1879.	*Grieve, Symington, 11 *Lauder Road.*
Dec. 1892.	*Gunn, Rev. George, M.A., *The Manse, Stitchel, Kelso.*
Mar. 1881.	‡Gunning, His Excellency Robert Halliday, M.A., M.D. Edin., 12 *Addison Crescent, Kensington, London.*
Feb. 1839.	‡Hamilton, John Buchanan, *of Leny and Bardovie.*
Dec. 1868.	Hardie, Thomas, M.D., F.R.C.P.E., 10 *John's Place, Leith.*
April 1862.	‡Hay, G. W. R., M.D., *Bombay Army.*
May 1887.	Hay, Henry, M.D., 7 *Brandon Street.*
June 1862.	†Haynes, Stanley, Lewis, M.D., *Medhurst, Malvern, Worcestershire.*
Dec. 1860.	‡Hector, Sir James, K.C.M.G., M.D., F.R.SS. L. & E., F.L.S., *Wellington, New Zealand.*
May 1841.	‡Heslop, Ralph C., M.D., 2 *Winckley Square, Preston, Lancashire.*
Dec. 1847.	‡Hewetson, Henry, *Leeds.*
April 1886.	Hill, J. R., *Secretary, Pharmaceutical Society, York Place.*
Dec. 1854.	‡Hill, W. R., M.D., *Lymington, Hants.*
May 1867.	*Hog, Thomas Alex., *of Newliston, Linlithgow.*
Dec. 1888.	*Hole, Henry E., *Quorndan Lodge, Loughborough.*
Feb. 1878.	†Holmes, E. M., F.L.S., F.R.H.S., *Curator of Museum, Phar. Soc. of Great Britain, Bradbourne Dene, Sevenoaks, Kent.*
Dec. 1841.	‡Holmes, Rev. E. Adolphus, M.A., F.L.S., *St. Margaret's, Harleston, Norfolk.*
Nov. 1884.	†Holt, G. A., 139 *Strangeways, Manchester.*
June 1850.	‡Hort, Fenton J. A., *Rev. Prof. D.D., St. Peter's Terrace, Cambridge.*
Dec. 1863.	‡Hossack, B. H., *Craigiefield, Kirkwall.*
Nov. 1873.	‡Hume, Thomas, M.B., C.M., *Madras.*

Date of Election.

Dec. 1890. Hunter, George, M.D., F.R.C.S.E., M.R.C.P.E., 33 *Palmerston Pl.*
Jan. 1860. ‡Hunter, Rev. Robert, LL.D., *Forest Retreat, Staples Hill, Loughton, Essex.*
June 1893. Hunter, Robert James, 24 *Craigmillar Park.*
Jan. 1851. ‡Hutchinson, Robert F., M.D., *Bengal.*
Jan. 1865. *Hutchison, Robert, F.R.S.E., 11 *Bellevue Crescent.*
Dec. 1847. ‡Ivory, Francis J., *Australia.*
Jan. 1855. ‡Jepson, O., M.D., *Medical Superintendent, City of London Lunatic Asylum, Stone, Dartford, Kent.*
Feb. 1891. ‡Jamieson, Thomas, *Lecturer on Agriculture, University, Aberdeen.*
May 1877. *Johnston, Henry Halcro, B.Sc., M.D., C.M., F.L.S., *Surgeon-Major, Army Medical Staff,* 1 *Great Wellington Street, Ferry Road.*
April 1858. ‡Johnston, John Wilson, M.D., F.R.S.E., *Dacre House, Shrewsbury Road, Oxton, Birkenhead.*
Nov. 1869. ‡Kannemeyer, Daniel R., L.R.C.S.E., *Burghersdrop, Cape Colony.*
Nov. 1877. Kerr, John Graham, *Christ's College, Cambridge.*
Mar. 1841. ‡Kerr, Robert, *Greenock.*
Jan. 1854. ‡Kirk, Sir John, K.C.B., M.D., F.R.S., F.L.S., *British Consul, Zanzibar.*
Jan. 1874. *Kirk, Robert, M.B., C.M., *Bathgate.*
Feb. 1856. ‡Lawson, George, LL.D., *Professor of Chemistry, Dalhousie University, Halifax, Nova Scotia.*
Feb. 1888. ‡Learmonth, W., *High School, Stirling.*
June 1874. *Leitch, John, M.B., C.M., *Silloth.*
Feb. 1878. ‡Lennox, David, M.D., *Crichton Royal Institution, Dumfries.*
April 1883. Lindsay, Robert, *Curator, Royal Botanic Garden;—Associate, July* 1879.
Feb. 1838. †Lingwood, Robert M., M.A., F.L.S., 6 *Park Villas, Cheltenham.*
Mar. 1874. Lister, Sir Joseph, Bart., F.R.SS. L & E., *Professor of Clinical Surgery,* 12 *Park Crescent, Portland Place, London, N.W.*
Jan. 1869. †Livesay, William, M.B., C.M., *Sudbury, Derby.*
June 1889. *Loudon, William, 14 *Belgrave Crescent.*
Feb. 1863. †Lowe, George May, M.D., C.M., *Lincoln.*
Jan. 1854. †Lowe, John, M.D., *Green Street, Park Lane, London.*
May 1838 ‡Lowe, William Henry, M.D., *Woodcote, Wimbledon.*
Dec. 1890. Lowson, J. Melvin, M.A., B.Sc., *University Tutorial College,* 32 *Red Lion Square, London, W.C.*
Jan. 1855. *Macadam, Stevenson, Ph.D., F.R.S.E., *Surgeons' Hall.*
May 1881. Macadam, W. Ivison, F.C.S., F.I.C., F.R.S.E., *Lecturer on Chemistry, Surgeons' Hall.*
Feb. 1892. M'Alpine, A. N., B.Sc. Lond., *Lecturer on Botany, Minto House.*
July 1836. ‡Macaulay, James, M.D., 22 *Cambridge Road, Kilburn, London, N.W.*
Mar. 1862. ‡Macdonald, John, M.D., F.L.S., *Gothic House, Walton-on-Thames.*
Jan. 1881. †Macfarlane, John M., Sc.D., F.R.S.E., *Professor of Botany, University of Philadelphia, U.S.A.*
Feb. 1886. M'Glashen, D., 79 *Morningside Park.*
Feb. 1863. ‡Macgregor, Rev. Patrick, M.A., *Logie-Almond Manse, Perthshire.*
June 1880. *M'Intosh, W. C., M.D., LL.D., F.R.SS. L. & E., F.L.S., *Professor of Natural History, St. Andrews.*
Jan. 1889. Mackenzie, A., *Warriston Nurseries.*
May 1862. ‡Mackenzie, Stephen C., M.D., *Professor of Hygiene, Calcutta.*
Nov. 1836. Maclagan, Sir Andrew Douglas, M.D., P.R.S.E., *Professor of Medical Jurisprudence,* 28 *Heriot Row.* — HONORARY SECRETARY.
April 1857. ‡Maclagan, General Robert, F.R.S.E., 4 *West Cromwell Road, South Kensington, London, S.W.*
April 1880. ‡M'Laren, John, jun., 15 *Mill Street, Perth.*
June 1850. M'Laren, Hon. Lord, 46 *Moray Place.*
Feb. 1882. M'Murtrie, Rev. John, M.A., D.D., 5 *Inverleith Place.*
Dec. 1887. Mann, Gustav, 4 *Great King Street.*
Dec. 1872. †Maw, George, F.L.S., F.G.S., *Benthall, Kenley, Surrey.*
May 1867. *Maxwell, Wellwood H., *of Munches, Dalbeattie.*
Nov. 1849. ‡Melville, A. G., *Emeritus Professor of Nat. Hist., Galway.*
April 1837. ‡Melville, Henry Reed, M.D., *St. Vincent.*
Jan. 1870. Methven, John, 6 *Bellevue Crescent.*
Feb. 1890. *Millar, R. C., C.A., 8 *Broughton Place.*

Date of Election.

Mar. 1883. Milne, Alex., 32 *Hanover Street.*
Nov. 1875. *Milne, John Kolbe, *Kevock Tower, Lasswade.*
Feb. 1874. Moffat, Andrew, 9 *Wilfrid Terrace.*
June 1888. Moffat, W. J., *Secretary, Scottish Aboricultural Society,* 5 *St. Andrew Square.*
Mar. 1853. †More, A. G., F.L.S., F.R.S.E., M.R.I.A., *Ex-Curator, Science and Art Museum,* 74 *Leinster Road, Dublin.*
Dec. 1888. Morris, Rev. A. B., F.L.S., 18 *Eildon Street.*
July 1878. †Muirhead, George, F.R.S.E., *Mains of Haddo, Aberdeen.*
Feb. 1881. Murray, George, *Chemist, South Back of Canongate.*
Dec. 1889. ‡Murray, J. Russel, *Port-of-Spain, Trinidad.*
May 1884. Murray, William, 8 *Clifton Terrace.*
Nov. 1848. ‡Nevins, John Birkbeck, M.D., 3 *Abercromby Square, Liverpool.*
Dec. 1878. *Norman, Commander Francis M., R.N., *Cheviot House, Berwick-on-Tweed.*
July 1889. Normand, P. Hill, *Whitehill, Aberdour, Fifeshire.*
May 1873. Ogilvie, William M'Dougall, *Royal Bank, Lochee, Dundee.*
June 1890. Oliver, John S., 12 *Greenhill Park.*
Feb. 1863. *Panton, Geo. A., F.R.S.E., 73 *Westfield Road, Edgbaston, Birmingham.*
July 1841. †Parker, Charles Eyre, 13 *Scarborough Terrace, Torquay, Devon.*
May 1867. †Paterson, Alexander, M.D., *Fernfield, Bridge of Allan.*
Trans. Dec. 1858 } ‡Paterson, R., M.D., *Napier Road;—Wernerian, Dec.* 1836.
Mar. 1880. ‡Paton, James, F.L.S., *Industrial Museum, Kelvingrove, Glasgow.*
April 1883. *Paul, Rev. David, M.A., *Roxburgh Manse, Kelso.*
Nov. 1839. ‡Paul, James, M.D., *Jamaica.*
July 1889. *Paxton, W., *Orchardton, Fountainhall Road.*
April 1880. Peach, B. N., F.R.S.E., F.G.S., *Scot. Geol. Survey Office,* 86 *Findhorn Place.*
Nov. 1840. ‡Perry, William Groves, *Australia.*
Mar. 1874. ‡Pettigrew, J. B., M.D., LL.D., F.R.SS. L. and E., *Professor of Medicine, St. Andrews.*
April 1887. Peyton, Rev. W. W., *Broughty Ferry.*
Jan. 1838. ‡Pires, D'Albuquerque, Le Chevalier, *Brazil.*
Dec. 1874. ‡Playfair, D. T., M.B., C.M., *Heathfield, Bromley, Kent.*
May 1883. ‡Playfair, Rev. Patrick M., *Glencairn Manse, Thornhill.*
July 1836. ‡Pollexfen, Rev. John Hutton, M.A., *Middleton Tyas Vicarage, Richmond, Yorkshire.*
April 1877. ‡Porteous, George M., *Firknowe, Juniper Green.*
July 1871. ‡Post, G. E., M.D., *Beyrout.*
Nov. 1873. *Potts, George H., *of Fettes Mount, Lasswade.*
June 1891. †Prain, David, M.D., F.L S., F.R.S.E., *Royal Botanic Garden, Shippur, Calcutta.*
Dec. 1849. ‡Priestley, Sir W. O., M.D., 17 *Hertford Street, Mayfair, London.*
‡Prior, R. C. Alexander, M.D., F.L.S., 48 *York Terrace, Regent's Park, London, and Halse House, Taunton.*
June 1893. ‡Pullar, Robert, J.P., F.R S.E., *Tayside, Perth.*
Dec. 1858. †Ramsbotham, S. H., M.D., *Leeds.*
July 1884. *Rattray, John, M.A., B.Sc, F.R.S E., *Dunkeld.*
Jan. 1878. ‡Reid, Jas. R., C.M.G., *Bengal Civil Service.*
April 1877. ‡Riddell, William R., B.A., B.Sc, *Prov. Normal School, Ottawa, Ontario, Canada.*
Dec. 1869. *Robertson, A. Milne, M.B., C.M., *Gonville House, Roehampton Park, London, S. W.*
Dec. 1890. Robertson, Robert A. M.A., B.Sc., *Lecturer on Botany, St. Andrews, Rattray, Perthshire.*
April 1864. Rutherford, William, M.D., F.R.SS. L. and E., *Professor of Physiology,* 14 *Douglas Crescent.*
Dec. 1864. †Rylands, Thomas Glazebrook, F.L.S., *Highfields, Thelwall, near Warrington.*
July 1882. *Sanderson, William, *Talbot House, Ferry Road.*
June 1893. Sanderson, Mrs. W., *Talbot House, Ferry Road.*
Mar. 1869. *Scot-Skirving, Robert, *of Camptown,* 29 *Drummond Place.*
May 1841. ‡Scott, D. H., M.D., *Altavilla, Queenstown, Cork.*
April 1881. ‡Scott, Daniel, *Wood Manager, Darnaway Castle, Forres.*
Dec. 1840. ‡Scott, John, *Greenock.*
Dec. 1887. Scott, J. S., L.S.A., 55 *Clowes Street, West Gorton, Manchester.*

Date of Election.

Dec. 1891. *Semple, Andrew, M.D., F.R.C.S.E., *Deputy Surgeon-General*, 10 *Forres Street*.
Feb. 1888. Sewell, Philip, 8 *Hanover Terrace, Whitby*.
May 1836. ‡Shapter, Thomas, M.D., *Sudbury, Derby*.
Dec. 1869. ‡Shaw, John Edward, M.B., 2 *Rodney Cottages, Clifton, Bristol*.
Mar. 1850. ‡Sherwood. E., M.D., *Prospect Hill, Whitby*.
Jan. 1851. *Sibbald, John, M.D., F.R.S.E., 3 *St. Margaret's Road*.
Nov. 1836. ‡Sidney, M. J. F., *Cowpen, Morpeth*.
Nov. 1840. ‡Simpson, Samuel, *Lancaster*.
Jan. 1887. Simson, W. B., *The Elms, Broughty Ferry*.
Jan. 1840. ‡Slack, Robert, M.D., *Holywalk, Leamington*.
Feb. 1891. *Smith, J. Pentland, M.A., B.Sc., *Horticultural College, Swanley, Kent*.
Mar. 1891. Smith, William G., B.Sc., 4 *Lorne Terrace, Maryfield, Dundee*.
Feb. 1886. †Somerville, Alexander, B.Sc., F.L.S., 4 *Bute Mansions, Hillhead, Glasgow*.
Jan. 1890. *Somerville, William, Œc.D., B.Sc., F.R.S.E., *Professor of Agriculture, Durham College of Science, Newcastle-on-Tyne*.
July 1853. ‡Southwell, Thomas, F.Z S., *Earlham Road, Norwich*.
Dec. 1854. ‡Spasshatt, Samuel P., M.D., *Armidale, New South Wales*.
June 1874. Sprague, Thomas Bond, M.A , F.R.S.E., 29 *Buckingham Terrace*.
June 1893. Sprague, Mrs. T. B., 29 *Buckingham Terrace*.
Nov. 1883. †Stabler, George, *Levens, Milnthorpe, Westmoreland*.
July 1867. ‡Steel, Gavin, *of Carphin, Lanarkshire*.
Mar. 1888. Steele, A. B., *Museum of Science and Art*.
Feb. 1841. ‡Steele, Robert, *Greenock*.
Jan. 1837. ‡Stevens, Rev. Charles Abbott, M.A., *Port Slade Vicarage, Shoreham, Sussex*.
Feb. 1871. ‡Stewart, Samuel A., *The Museum, College Square North, Belfast*.
July 1883. Stewart, John, *Letham Mill, Arbroath*.
Dec. 1892. Stewart, Robert, S.S.C., 7 *East Claremont Street*.
Jan. 1893. Struthers, John, M.D., LL.D., *Emeritus Professor of Anatomy*, 24 *Buckingham Terrace*.
July 1884. Stuart, Charles, M.D., *Chirnside*.
Dec. 1869. Syme, David, 1 *George IV. Bridge*.
July 1853. *Taylor, Andrew, 11 *Lutton Place*.
Dec. 1837. ‡Taylor, R. H., M.D., 1 *Percy Street, Liverpool*.
Dec. 1887. Terras, J. A., B.Sc., 40 *Findhorn Place*.—ASSISTANT SECRETARY.
June 1877. Thomson, David, *Craigleith Nurseries*.
June 1836. ‡Thomson, Spencer, M.D., *Ashton, Torquay*.
Feb. 1871. †Tinne, John A., *Briarley, Aigburth, Liverpool*.
April 1846. †Townsend, F., M.A., F.L.S., *Honington Hall, Shipston-on-Stour*.
May 1888. *Trail, J. W. H., M.A., M.D., F.L.S., *Professor of Botany, Aberdeen*.
Dec. 1890. Tress, W. Maxwell, 7 *Melville Crescent*.
Dec. 1888. Turnbull, Robert, B.Sc., 9 *Dean Terrace*.
Mar. 1836. ‡Tyacke, N., M.D., *Westgate, Chichester*.
Nov. 1888. Ure, George, *Camphill Lodge, Broughty Ferry*.
July 1886. †Waddell, Alexander, *of Pallace, Jedburgh*.
Jan. 1856. ‡Waddell, Thomas, *Cumbernauld*.
Dec. 1861. *Walker, Arthur A., *Chislehurst, Putney Common, London, S.W.*
Jan. 1856. ‡Walker, V. E., *Arno's Grove, Southgate, Middlesex*.
Mar. 1836. ‡Wallich, George Charles, M.D., *Kensington, London, W.*
Dec. 1884. *Watson, Charles, *The Clouds, Duns*.
July 1884. Watson, William, M.D., *Waverley House, Slateford*.
May 1885. ‡Webster, A. D., *Holwood Park, Keston, Beckenham*.
May 1837. ‡White, Alfred, F.L.S., *West Drayton*.
Dec. 1861. †White, F. Buchanan, M.D., F.L.S , *Annat Lodge, Perth*.
July 1891. White, R. Brooman, *Arddarroch, Dumbartonshire*.
Mar. 1893. †Wilkinson, W. H., F.L.S., F.R.M.S., *Rockville, Manor Hill, Sutton Coldfield, Birmingham*.
Mar. 1837. ‡Wilks, G. A. F., M.D., *Woodburn, Torquay*.
Mar. 1873. ‡Wilson, A. Stephen, *North Kinmundy, Summerhill, Aberdeen*.
Dec. 1890. *Wilson, John H., D.Sc., F.R.S.E , care of Hunter, 1B *Eildon Street*;—*Associate, Nov.* 1886.
April 1880. Wilson, Dr Andrew, F.R.S.E., F.L.S., 110 *Gilmore Place*.
July 1892. Wood, Lieut.-Col.-Surgeon Julius John, M.B.

Date of Election.
May 1873. ‡Wright, R. Ramsay, M.A., B.Sc., *Professor of Natural History, University, Toronto.*
May 1863. †Yellowlees, David, M.D., *Gartnavel Asylum, Glasgow.*

CORRESPONDING MEMBERS.

Date of Election.
Jan. 1878. Areschoug, Dr. F. W. C., *Professor of Botany in the University, and Director of the Botanic Garden, Lund.*
Jan. 1878. Ascherson, Dr. P., *Royal Herbarium, Berlin.*
April 1877. Blytt, Axel, *Professor of Botany in the University, and Conservator of the Botanical Museum, Christiania.*
Dec. 1881. Bohnensieg, Dr. G. C. W., *Conservator of the Library of the Museum Leyler, Haarlem.*
Jan. 1878. Bömmer, J. E., *Professor of Botany, Brussels.*
July 1879. Bornet, Dr. Edouard, Membre de l'Institut, For. F.L.S., *Paris.*
Dec. 1854. Brandis, Sir Dietrich, Ph.D., F.L.S., *Ex-Inspector-General of Indian Forests, Professor of Forestry in the University, Bonn.*
Mar. 1881. Caminhoá, Dr. Joaquim Monterio, *Professor of Botany and Zoology, Rio Janeiro.*
Jan. 1866. Candolle, Casimir de, *Geneva.*
July 1879. Cheeseman, T. F., F.L.S., F.Z.S., *Curator of the Museum, Auckland, New Zealand.*
July 1879. Cleave, Rev. W. O., LL.D., *College House, St. Helier, Jersey.*
May 1865. Clos, Dominique, M.D., Corresp. de l'Institut, *Professor of Botany in the Faculty of Sciences, and Director of the Botanic Garden, Toulouse.*
Dec. 1868. Crépin, François, *Director of the Royal Botanic Garden, Brussels.*
Jan. 1878. Eeden, F. W. Van, *Director of the Colonial Museum, Haarlem.*
Feb. 1893. Errera, Leo, *Professor of Botany in the University, Brussels.*
Jan. 1878. Garcke, Dr. A , *Professor of Botany in the University, and First Assistant in the Royal Botanic Museum, Berlin.*
April 1844. Gottsche, Dr. K. M., *Altona, Schleswig-Holstein.*
Jan. 1886. Haberlandt, Dr. G., *Professor of Botany in the University, and Director of the Botanic Garden, Graz.*
Dec. 1887. Hansen, Dr. E. C., *Director of the Physiological Department of the Carlsberg Laboratory, Copenhagen.*
Feb. 1876. Heldreich, Dr. Theodore de, *Director of the Botanic Garden, Athens.*
May 1891. Henry, Augustine, M.D., *Imperial Customs Service, China.*
April 1887. Horne, John, F.L.S., *Ex-Director of the Royal Botanic Garden, Mauritius.*
Jan. 1886. Janczewski, Dr. Ed. Ritter von, *Professor of Plant Anatomy and Physiology in the University, Cracow.*
July 1853. Jolis, Dr. Auguste le, *Cherbourg.*
Mar. 1878. Juranyi, Dr. L., *Professor of Botany in the University, and Director of the Botanic Garden, Buda Pest, Hungary.*
Jan. 1886. Kerner, Dr. Anton J. Ritter von Merilaun, *Professor of Botany in the University, and Director of the Botanic Garden, Vienna.*
April 1878. King, George, C.I.E , M.D., F.R.S., F.L.S., *Superintendent, Botanic Garden, Calcutta.*
Jan. 1886. Leichtlin, Max, *Baden-Baden.*
Jan. 1886. Luerssen, Dr. Ch., *Professor of Botany in the University, and Director of the Botanic Garden, Königsberg.*
Jan. 1873. Millardet, A., *Professor of Botany in the Faculty of Sciences, Bordeaux.*
Jan. 1878. Moore, Charles, F.L.S., *Director of the Botanic Garden, Sydney, New South Wales.*
Jan. 1866. Naudin, Dr. C., For. F.L.S., Membre de l' Institut, *Director of the Laboratory, Villa Thuret, Antibes.*
Jan. 1878. Nyman, Charles Frider, *Stockholm.*
Jan. 1878. Oudemans, Dr. C. A. J. A., *Professor of Botany in the University, and Director of the Botanic Garden, Amsterdam.*
Jan. 1886. Pfeffer, Dr. W., For. F.L.S., *Professor of Botany in the University, and Director of the Botanic Garden and Institute, Leipzig.*
Jan. 1872. Phillipi, Dr. R. A., *Professor of Botany in the University of Santiago, Chili.*
Dec. 1868. Radlkofer, Dr. L., *Professor of Botany in the University, Munich.*

Date of Election.

Mar. 1881. Rodrigues, Joas Barboza, *Director of the Botanic Garden, Rio Janeiro.*

Dec. 1858. Rostan, Dr. Edouard, *San Germano di Pinerolo, Piedmont.*

Mar. 1878. Sargent, C. S., *Professor of Arboriculture, Harvard University, Cambridge, and Director of the Arnold Arboretum, Brookline, Massachusetts.*

Feb. 1893. Schmitz, Fr., *Professor of Botany in the University, and Director of the Botanic Garden, Griefswald.*

Feb. 1876. Sodiro, Luis, *Professor of Botany in the University, Quito, Ecuador.*

Nov. 1888. Sully, W. C., *Cape Town.*

Dec. 1870. Suringar, W. F. R., *Professor of Botany, and Director of the Botanic Garden, Leyden.*

May 1876. Terracciano, Dr. Nicolao, *Director of the Royal Gardens, Caserta, near Naples.*

Jan. 1886. Treub, Dr. M., For. F.L.S., *Director of the Botanic Garden, Buitenzorg, Java.*

Nov. 1888. Tyson, W., *Forest Department, Cape Town.*

Dec. 1887. Wildpret, H., *Director of the Botanic Garden, Orotava.*

Dec. 1870. Willkomm, Dr. Maurice, *Professor of Botany and Director of the Botanic Garden, Prague, Bohemia.*

ASSOCIATES.

Dec. 1861. Bell, William, *New Zealand.*

Mar. 1886. Bennett, A., F.L.S., 107 *High Street, Croydon.*

Mar. 1848. Boyle, David, *Boxhill Post Office, Nunwading, South Bourk, Melbourne.*

Jan. 1853. Brocas, F. Y., 4 *Mill Street, Conduit Street, London, W.*

Feb. 1878. Buchanan, John, C.M.G., *Blantyre, Shiré Highlands, Central Africa.*

Feb. 1876. Campbell, A., 14 *Marchmont Crescent, Edinburgh.*

Mar. 1878. Campbell, John, *Ledaig, Argyllshire.*

Feb. 1871. Evans, William, *Scottish Widows' Fund, St. Andrew Square.*

Feb. 1841. Gray, Peter, 12 *Perth Street, Henderson Row.*

Dec. 1885. Greig, James, *Woodville, Dollar.*

Dec. 1850. Howie, Charles, *St. Andrews.*

Dec. 1873. Jaffray, Andrew T., *Darjeeling.*

Dec. 1840. Kerr, Andrew, *Taxidermist, Montrose.*

April 1847. Laing, J., *Nurseryman, Foresthill, London.*

Mar. 1886. Landsborough, Rev. D., *Kilmarnock.*

June 1891. M'Andrew, James, *New Galloway, Kirkcudbrightshire.*

Feb. 1890. M'Intosh, Charles, *Dunkeld.*

June 1845. M'Nab, T., *Montreal, Canada.*

Dec 1868. Munro, Robertson, *Glasgow.*

Mar. 1840. Pamplin, William, A.L.S., *Llanderfel, Corwen, Merionethshire.*

Dec. 1883. Richardson, Adam D., *Royal Botanic Garden.*

Mar. 1878. Ross, George, 18 *Crombie Street, Oban.*

June 1891. Shaw, James, *Tynron, Dumfriesshire.*

May 1868. Shaw, William, *Gunsgreen, Eyemouth.*

Dec. 1858. Sim, John, *Perth.*

Mar. 1886. Traill, G. W., 3 *George Street.*

April 1877. Whittaker, Joseph, *Ferriby Brook, Morley, Derby.*

LADY ASSOCIATE.

Nov. 1886. Ormerod, Miss E. A., *Dunster Lodge, Isleworth.*

LADY MEMBER.

April 1893. Balfour, Mrs. Bayley, *Inverleith House ;—Lady Associate,* 1886.

THE SOCIETY EXCHANGES PUBLICATIONS WITH—

AMERICA.

CANADA.

Halifax, . . . Department of Agriculture—Professor G. Lawson Secretary.
Nova Scotia Institute of Natural Science.
Montreal, . . Geological and Natural History Survey of Canada—Alfred R. C. Selwyn, Director.
Natural History Society.
Toronto, . . Canadian Institute.

COSTA RICA.

San Jose, . . Museo Nacional.

UNITED STATES.

Boston, . . . Boston Society of Natural History.
Massachusetts Horticultural Society.
Cambridge, . Harvard University.
Cincinnati, . Cincinnati Society of Natural History.
Crawfordsville, Editor of *Botanical Gazette*.
Davenport, . . Davenport Academy of Natural Sciences.
New Haven, . Connecticut Academy of Arts and Sciences.
New York, . . American Museum of Natural History.
Columbia College.
New York Academy of Sciences.
Torrey Botanical Club.
Philadelphia, . Academy of Natural Sciences.
St. Louis, . . Missouri Botanic Garden.
San Francisco, California Academy of Sciences.
Sacramento, . California State Board of Forestry.
Topeka, . . . Kansas Academy of Science.
Trenton, . . Trenton Natural History Society.
Washington, . United States Geological Survey — T. W. Powell, Director.
Smithsonian Institution.
United States Department of Agriculture, Section of Vegetable Pathology—B. T. Galloway, Chief.

ASIA.

Calcutta, . . Botanic Garden.

AUSTRALASIA.

NEW SOUTH WALES.

Sydney, . . . Royal Society of New South Wales.

NEW ZEALAND.

Wellington, . Colonial Museum and Geological Survey.
New Zealand Institute.

QUEENSLAND.

Brisbane, . . Royal Society of Queensland.

TASMANIA.

Hobart, . . . Royal Society of Tasmania.

VICTORIA.

Melbourne, . . Royal Society of Victoria.

EUROPE.

AUSTRIA.

Cracow, . . Academija Umiejetnósci.
Graz,. . . . Naturwissenschaftlicher Verein für Steiermark.
Vienna. . . . K. K. Naturhistorisches Hofmuseum.
K. K. zoologisch-botanische Gessellschaft.

BELGIUM.

Brussels, . . Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique.
Société Royale de Botanique de Belgique.
Federation des Sociétés d'Horticulture de Belgique.
Ghent, . . . Editor of *Botanische Jaarboek*.

DENMARK.

Copenhagen, . Botaniske Forening.

FRANCE.

Amiens, . . . Société Linnéenne du Nord de la France.
Cherbourg, . . Société Nationale des Sciences Naturelles et Mathematiques.
Courrensan, . Société Française de Botanique.
Lyons, . . . Société Botanique.
Paris, . . . Société Botanique de France.
Société Linnéenne de Paris.

GERMANY.

Berlin, . . . Botanischer Verein für die Provinz Brandenburg und die angrenzenden Länder.
Bonn, . . . Naturhistorischer Verein der preussischen Rheinlande, Westfalens, und der Reg.-Bezirks Osnabruck.
Braunschweig, . Verein für Naturwissenschaft.
Bremen, . . . Naturwissenschaftlicher Verein.
Breslau, . . . Schlesische Gesellschaft für vaterlandische Cultur.
Erlangen, . . Physikalisch-medicinische Societät.
Frankfort-a-Oder, Wissenschaftlicher Verein des Regierungsbezirks.
Giessen, . . . Oberhessische Gesellschaft für Natur- und Heilkunde.
Halle, . . . Kais. leopoldinisch-carolinische deutsche Akademie der Naturforscher.
Kiel, ... Naturwissenschaftlicher Verein für Schleswig-Holstein.
Königsberg, . Kön. physikalisch-oekonomische Gesellschaft.
Munich, . . . Baierische Gesellschaft.

GREAT BRITAIN AND IRELAND.

Alnwick, . . Berwickshire Naturalists' Club.
Belfast, . . . Natural History and Philosophical Society.
Belfast Naturalists' Field Club.
Bristol, . . . Bristol Naturalists' Society.
Buckhurst Hill, Essex Field Club.

Dublin, . . .	Royal Dublin Society.
Dumfries, . .	Dumfriesshire and Galloway Natural History and Antiquarian Society.
Edinburgh, . .	Royal Scottish Arboricultural Society.
	Royal College of Physicians.
	Edinburgh Geological Society.
	Royal Society of Edinburgh.
	Royal Physical Society.
	Royal Scottish Geographical Society.
	Royal Scottish Society of Arts.
Glasgow, . .	Natural History Society.
	Philosophical Society.
Hertford, . .	Hertfordshire Natural History Society and Field Club.
Leeds, . . .	Yorkshire Naturalists' Union.
Liverpool, . .	Literary and Philosophical Society.
London, . . .	Editor of *Gardeners' Chronicle*.
	Linnean Society.
	Editor of *Nature*.
	Pharmaceutical Society of Great Britain.
	Queckett Microscopical Club.
	The Royal Society.
	Royal Gardens, Kew.
	Royal Horticultural Society.
Manchester, .	Manchester Literary and Philosophical Society.
Newcastle-upon-Tyne, .	Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne, and the Tyneside Naturalists' Field Club.
Norwich, . .	Norfolk and Norwich Naturalists' Society.
Perth, . . .	Perthshire Society of Natural Science.
Plymouth, . .	Plymouth Institution.

Holland.

Amsterdam, .	Koninklijke Akademie van Wettenschappen.
Haarlem, . .	Musée Teyler.
	Nederlandische Maatschappij ter Bevordering van Nijverheid.
Luxembourg, .	Société Botanique du Grand-duché de Luxembourg.

Italy.

Rome, . . .	Reale Instituto Botanico.

Portugal.

Lisbon, . . .	Academia real das Sciencias.

Russia.

Helsingfors, .	Societas pro Fauna et Flora Fennica.
Kieff, . . .	Société des Naturalistes.
Moscow, . .	Société impériale des Naturalistes.
St. Petersburg,	Hortus botanicus imperialis.

Scandinavia.

Lund, . . .	Universitas Lundensis.
Stockholm, . .	Kongl. Svenska Vetenskaps Akademien.
Upsala, . . .	Societas Regia Scientiarum.

Switzerland.

Berne, . . .	Naturforschende Gesellschaft.
Geneva, . . .	Herbier Boissier.

INDEX.

TRANSACTIONS AND PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH.